First Lessons in Concrete Work

A booklet of practical information about small concrete jobs

by HAROLD E. SMITH

THIS BOOKLET is intended to furnish practical and specific directions as to the construction of floors, sidewalks, walls and other light concrete work, with information as to methods of mixing concrete, its ingredients, and the proportions used. Some data is included as to the cost of concrete construction in its simplest forms. We cannot of course begin to cover all the problems of concrete construction in this booklet, but will cheerfully furnish further information upon request.

We are indebted to the UNIVERSAL PORTLAND CEMENT CO., for a great deal of the information contained in this booklet and also for most of the illustrations. We also wish to acknowledge the valuable assistance of Mr. S. M. Siesel of Milwaukee, in preparing data as to the cost of concrete construction.

THE T. L. SMITH COMPANY
MILWAUKEE, WISCONSIN

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CONCRETE

Choice of Building Materials. The widespread use of concrete is due to two primary causes: First, the general recognition by experts of the superiority of concrete over other materials for building purposes; and Second, the daily increasing shortage of lumber and hence its high price. In the days when concrete construction was more expensive, the excuse for not building of concrete was because of its cost. This excuse has now ceased to exist, since the cost of concrete construction does not greatly exceed the cost of wood in any locality. If lower insurance premiums and future repair bills are considered, there is no doubt but that concrete is actually cheaper than wood.

Ingredients Used. By concrete, we mean a mixture of cement sand, crushed stone, and water, in certain standard proportions. Screened gravel is an excellent substitute for crushed stone. Often pit run gravel is used instead of stone and sand; but it is not recommended as a rule, because the percentages of sand to stone vary widely. An ideal pit run gravel is about 40 per cent sand. Since there is usually too much sand in proportion to the pebbles, cement is saved, and a better concrete is obtained, by screening the sand from the pebbles, and then remixing them in correct proportions. All pebbles larger than one and one-fourth inches in diameter are usually discarded; all material less than one-fourth inch is considered sand. When the materials are mixed together, the resulting mixture is poured into forms and allowed to harden into the desired shape.

The sand used in concrete should be clean and free from clay and other foreign material. One may obtain some idea of its cleanliness by placing it in the palm of one hand and rubbing it with the fingers of the other. If the sand is dirty, it will discolor the palm. To test sand, fill a fruit jar with it to the depth of four inches. Add water until it is within one inch of the top. Shake well and allow to settle. If the layer of mud on top of the sand is one-half inch in thickness, the sand should not be used until it is washed. Preference should be given to sand containing a mixture of coarse and fine grains. Extremely fine sand can be used alone, but it makes a weaker mortar than either coarse sand alone or a mixture of coarse and fine sand. In size of grain, sand should grade from one-fourth inch in diameter down. If a large quantity of fine sand is convenient, get a coarse sand and mix the two together in equal parts. This mixture will produce satisfactory results, and at the same time will make a saving in the quantity of cement necessary. The cement must be kept dry until used. Wet cement will set and is then worthless for use in concrete.

For top dressing and wearing surfaces, where a smooth surface is desired, a mixture of cement, screened sand and water is placed on top of the coarser concrete. For convenience sake, however, this aggregate is called cement mortar, the term concrete being left to apply to the coarser aggregate.

Proportions. The proportioning of the various ingredients in concrete varies with the character of the work. However, there is one foundation principle underlying all formulae for making concrete, viz: There must be enough sand to completely fill the spaces between the pieces of stone and enough cement to coat both stone and sand, and to fill a large proportion of all remaining spaces.

Accordingly the sand and stone should be proportioned to form a solid mass without air-spaces. For a small job, fix the proportion of cement to sand conservatively, so as to be certain of ample strength in the concrete; and then use twice as much gravel or broken stone as sand. This formula is sufficiently accurate for ordinary requirements. The amount of water used will vary with every condition of the work and must be estimated separately for each class of work, as discussed later.

As a rough guide, to determine the quantity of cement advisable in various classes of work, we may take four proportions which differ from each other simply in the relative quantity of cement.

A Rich Mixture, for reinforced engine or machine foundations subject to vibration, for reinforced floors, beams and columns for heavy loading, tanks and other water-tight work, use 1:2:4 mix, that is, one part cement, 2 parts sand, 4 parts stone or screened gravel.

A Medium Mixture, for ordinary machine foundations, thin foundation walls, building walls, arches, ordinary floors, sidewalks, and sewers—proportions 1:2½:5.

An Ordinary Mixture, for heavy walls, retaining walls, piers and abutments, which are to be subjected to considerable strain—proportions 1:3:6.

A Lean Mixture, for unimportant work in masses where the concrete is subject to plain compressive strain, as in large foundations supporting a stationary load or backing for stone masonry—proportions 1:4:8.

Voids. Where an uncommon size or grade of stone or sand is used for concrete, it is advisable to determine the percentage of voids in both sand and stone before deciding upon the proportions to be used for the concrete. All sand contains voids, the percentage varying from 26 to 50 per cent. The percentage of voids in broken stone and gravel also varies, from 45 to 55 per cent, although gravel sometimes has as little as 30 per cent and usually not more than 45 per cent of voids.

The following is a simple method of testing for voids, recommended by the Railway Educational Bureau: "If a water-tight box is made, having a capacity of one cubic foot, and this box is filled with some of the sand which is to be tested for voids, the proportion of voids may be determined by pouring water into the box after it has been filled with dry sand moderately packed in place. Before pouring in the water it should be accurately measured, so that the amount necessary to fill the voids can be definitely known. If out of

SMITH DUO-CONE MIXERS

The engineers on the world-famous Key West Extension of the Florida East Coast Railway used **twelve big Smith Mixers** to complete their work; but they had an immense big undertaking.

Every contractor who builds a sidewalk, puts in curb and gutter, or a small foundation, is obliged to mix just as good concrete as the engineers on the big projects and, in addition, must figure on a profit. So, large or small, each job requires the best of equipment, as well as brains, to carry it on to a successful conclusion. The wise contractor chooses a mixer that has demonstrated its ability on every class of work—he takes a Smith and makes sure of his profits.

The Smith Mixer, with its duo-cone drum and tilting discharge, is built in nine sizes. These range from the Smith Mascot, Figure 3112, which holds four cubic feet of mixed concrete per batch, to the "big fellow," the No. 162, holding sixty-two cubic feet of mixed concrete per batch.

Send for Smith Mixer Catalog No. 66 or Smith Mascot Catalog No. 97.

SMITH MIXER CAPACITIES, WEIGHTS, ETC.

Number of Mixer	104	106	110	113	117	122	131	140	162
Size of batch, mixed concrete, cu. ft.	4	6	10	13	16½	22	31	40	62
Practical proportions	1:2:3	1:3:5	2:4:8	2:6:12	3:7:15	4:10:20	5:15:27	7:18:35	8:24:48
Output loose material per hour, cu. yds.	6½	9	16½	22½	27½	37	52	67	104
H. P. required	2	4	6	8	10	14	18	25	35
Speed of drum, R. P. M.	18	16	14	13	12	11	10	10	9

Complete table will be found listed in our large catalog. Ask for Smith Mixer Catalog No. 66 or Smith Mascot Mixer Catalog No. 97.

The T. L. Smith Co.—1164 Thirty-second Street—**Milwaukee, Wis.**

a pailful containing three gallons, there is half a gallon remaining after pouring enough into the box of sand to fill the voids, it will be known that the voids in the sand are equal to the bulk of 2½ gallons of water. The quantity of water poured into the box, divided by the quantity of water alone which the box will hold, represents the proportion of voids.

For accurate results in making this kind of test, the sand should be dried to expel all moisture, because any moisture present affects both the weight and the volume of the sand. The volume of water which it is found possible to add to the box containing the sand in order to fill the box to the point of overflowing, will represent the **volume** of the voids in the cubic foot of sand. The same method may be used to determine the percentage of voids in gravel or crushed stone."*

A very simple and accurate method employed by the Aberthaw Construction Co., Boston, Mass., for determining the voids in sand and broken stone for concrete work is as follows:

Apparatus necessary—a galvanized iron ash can and platform scales that will weigh up to at least 500 pounds.

Weigh can empty and indicate weight by W.

Weigh can filled with water and indicate weight by W2.

Weigh can filled with stone and indicate weight by W3.

Weigh can filled with stone and water and indicate weight by W4. Subtract W. from W2 and divide by 62.4 to find the number of cubic feet in the can; indicate by C. Subtract W3 from W4 to find the number of pounds of water required to fill the voids in the stone or sand; divide by 62.4 to reduce to cubic feet and indicate by V.

The C divided by V will give the percentage of voids in the stone. This method is used extensively by the Aberthaw Construction Company, and is accurate, convenient and quick.

THE MIXING OF CONCRETE.

Concrete can be mixed either by hand or by the use of a concrete mixer. It is a generally acknowledged fact that machine-mixed concrete is far superior in strength and uniformity to concrete mixed by the old method of the "shovel and the board." It is also generally admitted that concrete can be mixed and placed at a considerably less cost per yard by machine than by hand. Architects throughout the country have practically eliminated the use of hand mixing on most concrete work by specifying that a batch-concrete mixer must be used. Good concrete **can** be mixed by hand; but to get first-class results, so much turning is necessary, as to make the cost prohibitive. It has been found that hand mixing requires the closest inspection, as the temptation is great, on account of the difficulty of the work, to ease up on

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* FOOT NOTE: A gallon of water weighs 8.34 pounds and contains 231 cubic inches. A cubic foot is equal to 1728 cubic inches. As in the foregoing illustration, 2½ gallons of water were required to fill the voids in the cubic foot of sand, the volume of the voids therefore is equal to 577½ cubic inches (231 x 2½), and the percentage of voids is equal to 577½ divided by 1728, or approximately 33 per cent.

the quality of the mix. This inspection must be by an experienced foreman or by the owner himself. When the mixing is done by machine, the mixer makes it easy to keep an accurate check on the work done, and the most inexperienced labor can be used with only ordinary supervision.

More cement must be used for a hand mix than for a machine mix, since part of the water and cement is invariably lost in hand mixing. For the same reason it is impractical to mix wet concrete by hand unless it is done in a closed water-tight box. However, the hand mix is still extensively used throughout the country, so it is only proper that a discussion of this method be given in these pages.

Mixing by Hand. There are two methods common in hand mixing. The first is the board mix, which is by far the most satisfactory. The second we will call for convenience the "pile mix." The "pile mixing" method is very inefficient and unsatisfactory, because the materials separate and roll down the pile, and on account of the danger of dirt working into the aggregate during the mixing process. In fact, it is almost impossible to mix concrete thoroughly by this method. The board mix is somewhat better than the pile method, so we will confine our discussion to the former.

A tight platform should be provided for mixing, and this platform should be big enough for the handling of two batches at the same time, where the gang used is large enough to permit of this. Where possible, the platform should be near the point where the concrete is to be deposited, so that the mixed material may be deposited as soon as possible after mixing. Each "mix" of concrete is called a "batch." Batches mixed by hand should not exceed one cubic yard, and smaller ones are preferable.

The proper amount of sand should first be deposited on the platform in a round shaped mass not over 6 inches in thickness and the cement placed evenly on top of the sand. Then, starting at the outside, the materials should be turned over four or five times with the shovel, until thoroughly mixed. In the final turning the material should be deposited in a ring of about 4 foot diameter, leaving in the center a sort of basin to receive and retain the water. When the proper amount of water is placed in the "basin," the rim of cement and sand should be gradually shovelled into the water, great care being taken to see that no water is lost. If not well mixed when this is done, it will be necessary to turn it over again, leaving the mass when ready for the stone in the same flat circular shape as when the cement and sand were mixed in the beginning. The stone should be thoroughly wet and then distributed evenly on the pile, and the entire mass turned over three or four times until thoroughly mixed.

The above method of hand mixing is recommended by authorities on this style of concrete mixing. It is more thorough, but also more expensive than the methods often employed, the difference being chiefly in the number of times the material is turned. Good concrete, however, cannot be produced with less hand mixing than that specified above; and we cannot conscientiously recommend any "short cut" process.

SMITH HAND BATCH MIXER


1022

The Smith Hand Batch Mixer is the ideal mixer for the contractor who is just breaking into concrete work—for the concrete contractor whose jobs are small and scattered—for the large contractor, to finish up the tail-end of his work—for telephone companies, electric light and gas companies, industrial plants, railroads, etc. Run the Smith Hand Mixer over the forms and discharge directly into place. Eliminate the usual number of men and barrows required to wheel the mixed concrete into place. Look at the big saving where the Smith Hand Mixer is mounted over the foundation forms, straddled over the conduit ditch, figure 1022, or run between the sidewalk forms and the concrete discharged directly into place.

Four men and a Smith Hand Mixer can easily turn out from 30 to 35 cubic yards of perfectly mixed concrete daily—2½ cubic feet of mixed concrete to the batch—30 to 40 batches per hour. It is light and portable, weighs only 1,000 lbs. and can be moved about with ease. Send for special Hand Mixer Catalog No. 3.

Fig. 1023

The T. L. Smith Co.—1164 Thirty-second Street—**Milwaukee, Wis.**

When mixing cement mortar by hand, a water-tight box must be used to prevent loss of material. The proper proportions of screened sand and cement should first be mixed dry by working the material with a hoe. The water should then be added in sufficient quantity to make the material spread easily, but not flow too readily. It is most important that mortar be thoroughly mixed, since it forms the wearing surface, and has to bear the brunt of the wear.

Machine Mixing. Mechanical mixers for making concrete are in general use throughout all civilized countries. The advantages of machine mixing are as follows:

1. Better mixing.
2. Fifty per cent less time required for mixing.
3. No loss of materials.
4. Wetter mixes can be used.
5. Fifty per cent saving in labor.
6. Less inspection and supervision necessary.
7. Less danger of foreign materials working into the concrete.
8. Less cement required for mix of given strength.
9. Easier to get and keep men.

Mixers. There are many makes of mixing machines on the market, but in general they may be divided into two classes, namely: BATCH MIXERS and CONTINUOUS MIXERS. A batch mixer is to be preferred. Most architects and engineers forbid the use of continuous mixers on all work of importance. A batch mixer, as the name implies, takes one complete charge at a time, mixes the charge or batch and discharges it before further materials are introduced. Continuous mixers feed and discharge continuously, relying on automatic measuring devices to proportion the aggregate. Engineeers agree that a mixer should possess the following essentials:

1. Facility of charging.
2. Thorough and rapid mixing of the ingredients.
3. Rapid and complete discharge of the concrete.
4. Simple and sturdy construction.
5. Portability.

There are many mixers made, but only those possessing the above qualities are efficient and economical for concrete work.

Smith Hand Mixer. For work of a light nature, where 25 to 30 cubic yards of concrete per day are sufficient for the work, we recommend the SMITH HAND MIXER. It possesses all the necessary qualities enumerated above, and because of its light weight—1,000 pounds—and low price—$120.00 complete—it is peculiarly adapted for use by industrial concerns desiring to do their own concrete work. The following are some of the 105 concerns using SMITH HAND MIXERS for their own concrete work:

General Electric Co. .... Erie, Pa.
Hershey Milk Chocolate Co. .... Hershey, Pa.

Michigan Central R. R. .... Kensington, Ill.
Penn. Water and Power Co. .... Castle Fin, Pa.
Cambria Mining Co. .... Bellaire, Ohio.
Eastman Kodak Co. .... Rochester, N. Y.
Edison Electric Co. .... Lancaster, Pa.
Northwestern Telephone Exchange Co. . Crookston, Minn.

The Smith Hand Mixer is not recommended as a substitute for power-driven mixers. When the amount of concrete work to be done warrants the investment, we recommend a power machine. The SMITH MIXERETTE and the SMITH MASCOT MIXER, both illustrated and described in this book, are recommended when a small engine-driven mixer is necessary.

Operating a Mixer. The operation of a concrete mixer is a very simple matter, consisting mostly in getting the material to the mixer and away from it.

Where a SMITH HAND MIXER is used, or a power mixer equipped with a self-loading device, no charging platform is necessary. The SMITH HAND MIXER comes equipped with a platform, and a plank to be used as a runway is all that is necessary. The self-loading attachments on most power mixers can be charged from ground level. Where a mixer is used with a feed chute or batch hopper, the material is usually shoveled directly into the chute or hopper, providing that the material pile can be placed near enough to the mixer. However, if the material must be wheeled to the machine in wheelbarrows, it will be necessary to build a loading platform and runway.

Fig. 1

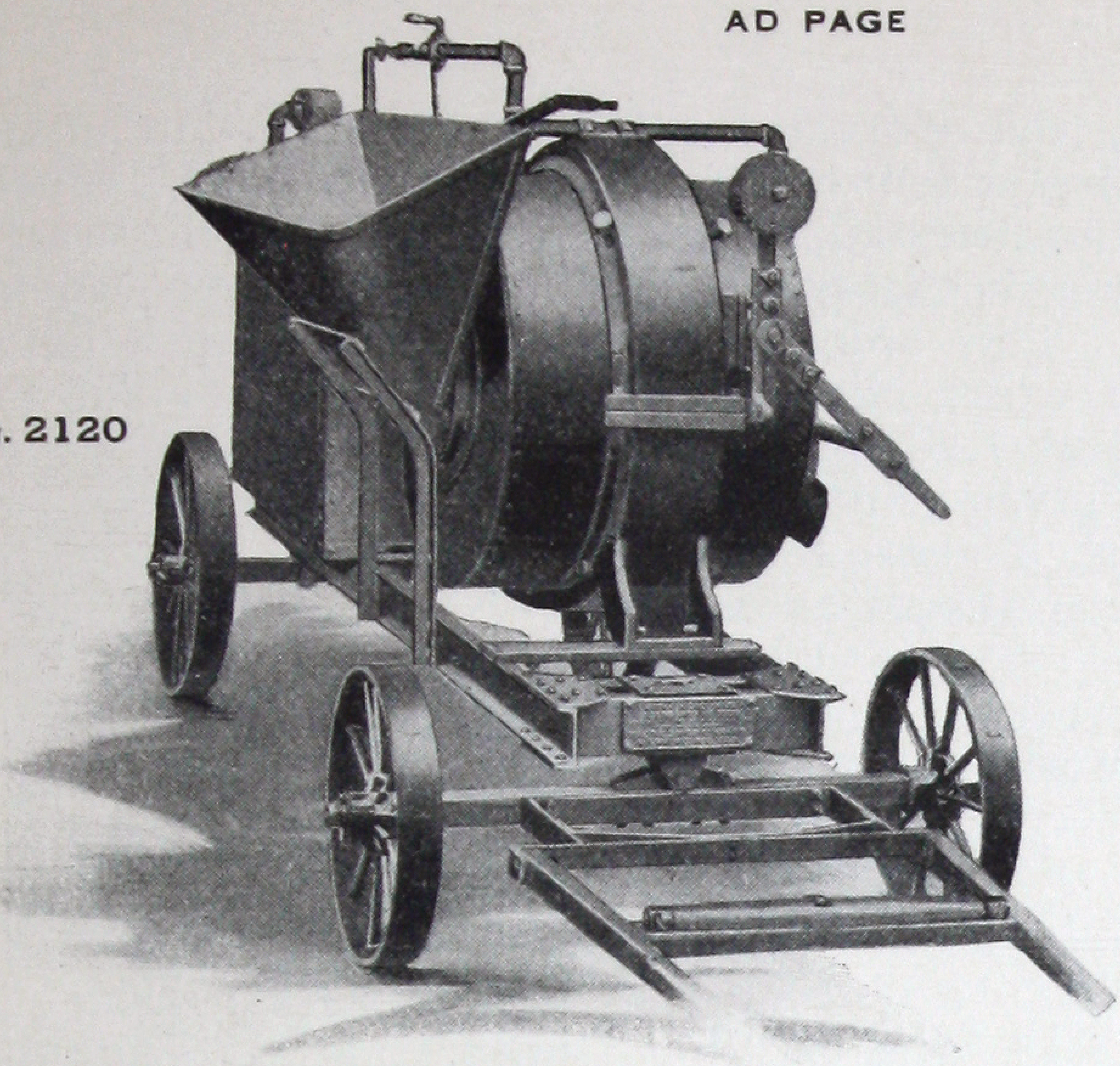


Fig. 2120

THE SMITH MIXERETTE

"Efficiency Plus" describes the Smith Mixerette to a dot. It is specially designed to meet the demand for a light, portable and inexpensive mixer. Efficiency is the keynote of its construction—efficiency plus merit. This merit has enabled the Smith Mixer to stand up against the hardest kind of usage on the most important projects in the country during the past fourteen years.

Two features in the construction of the Smith Mixerette stand out prominently. There are no rollers supporting the drum. The big dust-proof casing supports the drum, forms a perfect sliding bearing and effectually protects the bearing and driving pinion.

The gear-driven loader lifts easily. With its long, sloping sides and wide mouth, it discharges readily into the drum.

There are many other splendid features shown in our catalog. Send for it—Smith Mixerette Catalog No. 108.

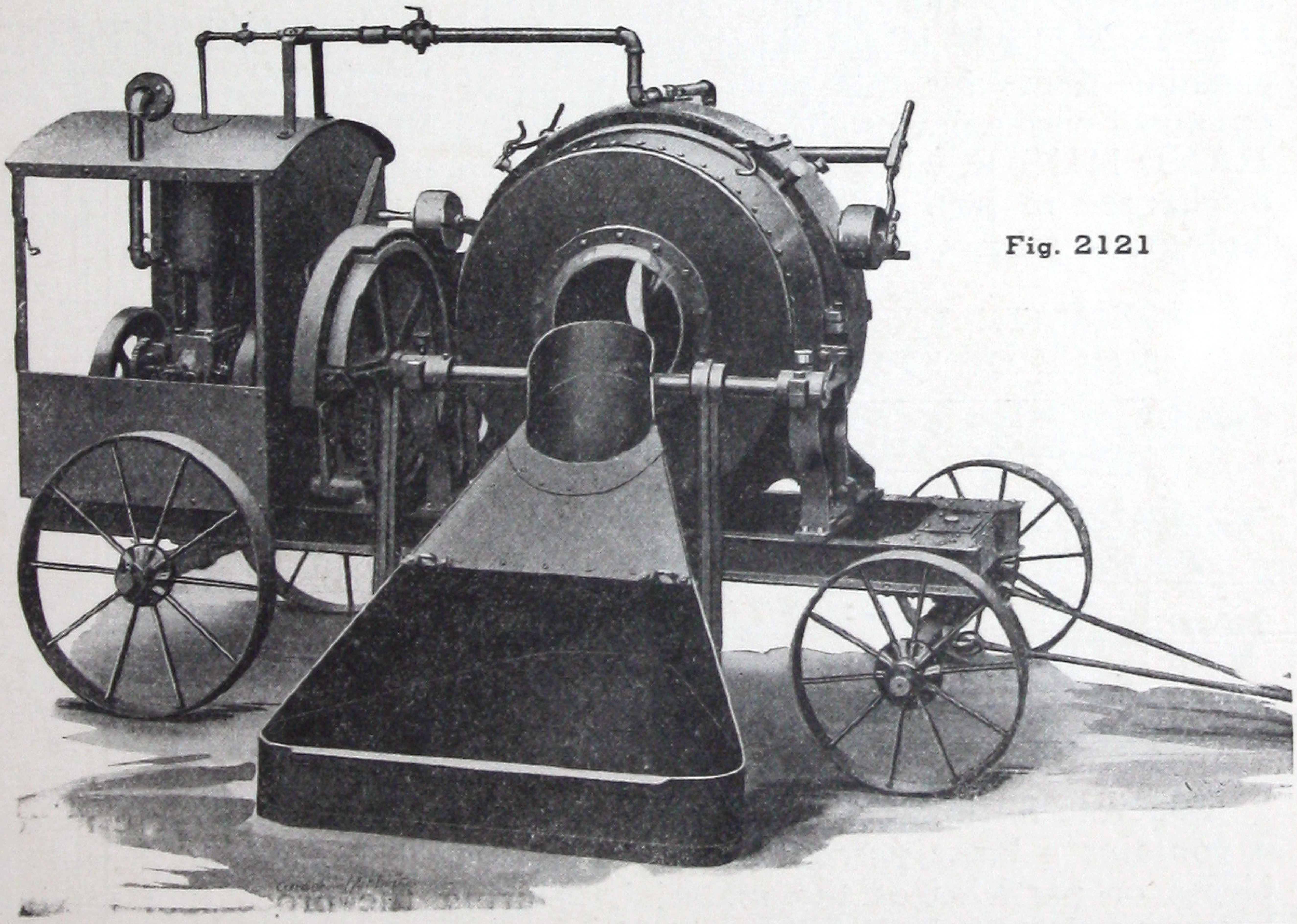


Fig. 2121

The T. L. Smith Co.——3133 Hadley Street——**Milwaukee, Wis.**

Where an ordinary feed spout is used, it is better to put in the materials in the following order: water, stone, cement, sand. Where a self-loader is used, the material, with the exception of the water, is placed in the loader, the sand in the bottom, then the cement and the stone on top. This order is reversed when using a batch hopper. The order in which the materials enter the drum of the mixer, however, is not of vital importance, the suggestions being given only to facilitate entry into the drum. To keep the mixer clean, however, **the water should always be put in first.**

The batch can be conveyed from the mixer to the forms in wheelbarrows or concrete carts; but, wherever it is practicable, it will be found cheaper and more convenient to place the mixer near the work and chute the concrete into the forms.

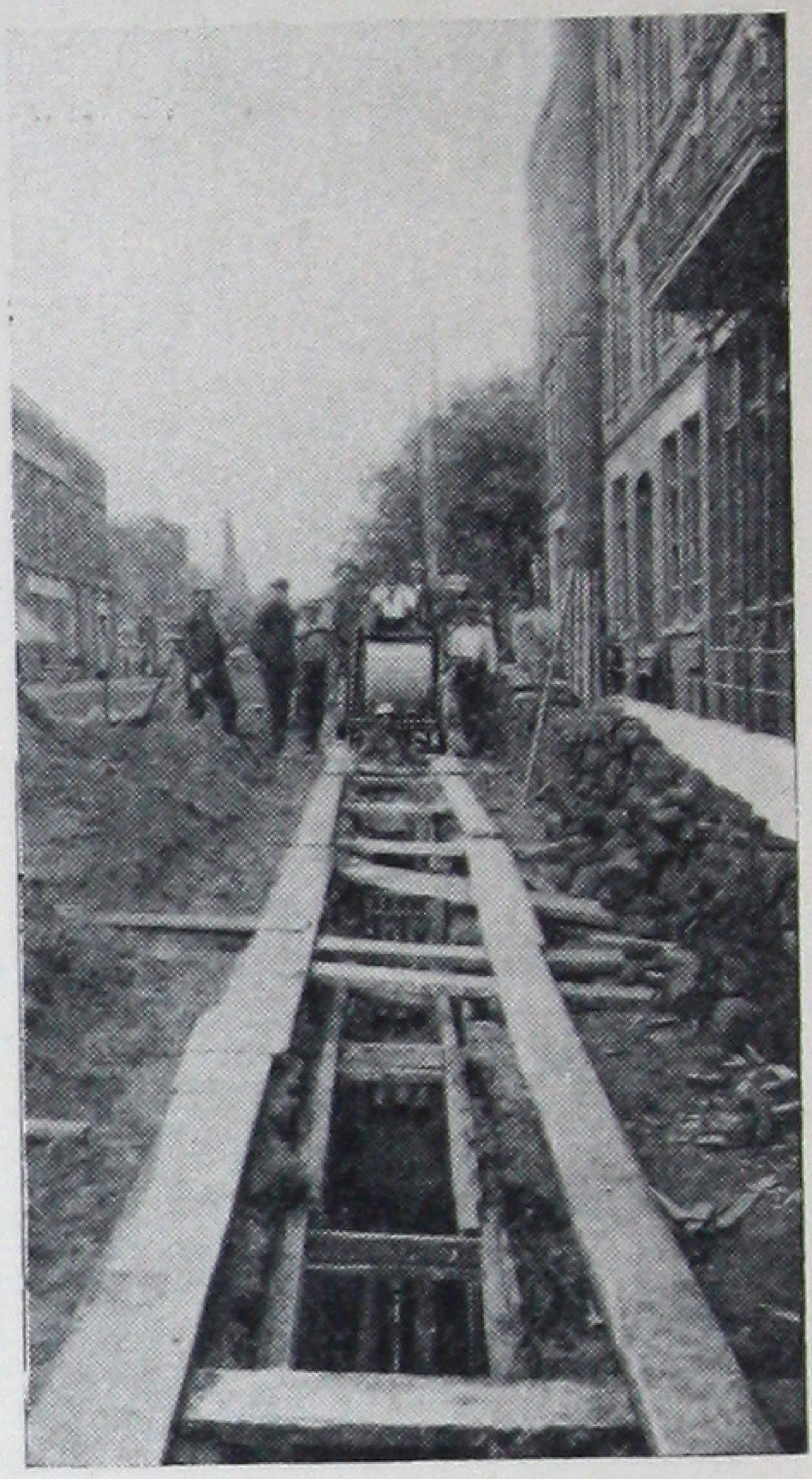


Fig. 2—Smith Hand Mixer placed over excavation for telephone underground conduit system. Concrete is discharged directly into the excavation.

This can be done very easily with the SMITH HAND MIXER, by reason of its light weight. It discharges underneath the drum and hence can be placed right over the forms, as shown in the accompanying illustration. When the mixer is stopped for any length of time it should be thoroughly cleaned. This is best done by running it with a batch of crushed stone and water in the drum. The SMITH HAND MIXER is provided with special cleaning doors for this purpose. A mixer equipped with a power charger, or a SMITH HAND MIXER, when properly operated should be loaded, mixed and discharged in from 1 to 1¼ minutes. A table of capacities for all high-grade mixers is given below:

APPROXIMATE TABLE OF CAPACITIES IN CUBIC YARDS PER HOUR OF STANDARD HIGH GRADE BATCH MIXERS

Capacity of Mixer per Mixed Batch	Without Side Loader or Batch Hopper			With Side Loader or Batch Hopper		
	4 Men	6 Men	8 Men	4 Men	6 Men	8 Men
Smith Hand Mixer—2½ Cubic Feet	2	2½	3	...	...	..
Power Mixer 3 cubic feet....	3	3½	4	4	4½	5
Power Mixer 4 cubic feet....	4	4½	5	4½	5½	6
Power Mixer 6 cubic feet....	6	8	9	7	9	11

Concrete Shrinkage. When material is put into a concrete mixer, it contains a large percentage of voids—that is, spaces between the pieces or particles of the material. During the process of mixing, however, the sand fills the voids in the stone, and the cement and water partially fill the voids in the sand, the result being a compact

mass. This process results in a considerable shrinkage in the volume of the material. For example, where 5 feet of coarse crushed stone are used, with 3 feet of sand, one foot of cement, and a considerable quantity of water, 9 feet of dry, **unmixed** material will shrink to about 6.5 feet of **mixed** concrete.

Many mixers are rated at their capacity in unmixed material, others are rated in "loose material" without specifying where mixed or unmixed material is meant. Since the percentage of voids in different kinds of gravel and stone is such a variable quantity, it is impossible to rate the capacity of a mixer accurately in unmixed materials. Prospective buyers, to safeguard their own interests, should always ascertain carefully the "wet" capacity of the mixer—that is, the amount it will hold per batch in cubic feet of MIXED CONCRETE.

FOUNDATIONS.

Excavating. Every foundation should extend below the point reached by frost. The Universal Portland Cement Co. make the following recommendations concerning excavations for a foundation: "Unless the natural drainage of the soil is poor it will be unnecessary to excavate to a depth of more than 3 feet, provided solid earth is found at that depth. A foundation must be established on solid ground, all loose earth or loam being removed. Excavating for a foundation until a suitable earth footing is secured may result in an uneven bottom in the foundation trench, but when concrete is used, the construction will progress the same on an uneven as on an even bottom."

Forms. Wherever the foundation is to project above ground level, forms must be used, in which to place the concrete. Very often the excavation is in soil which will stand in a vertical position. In such

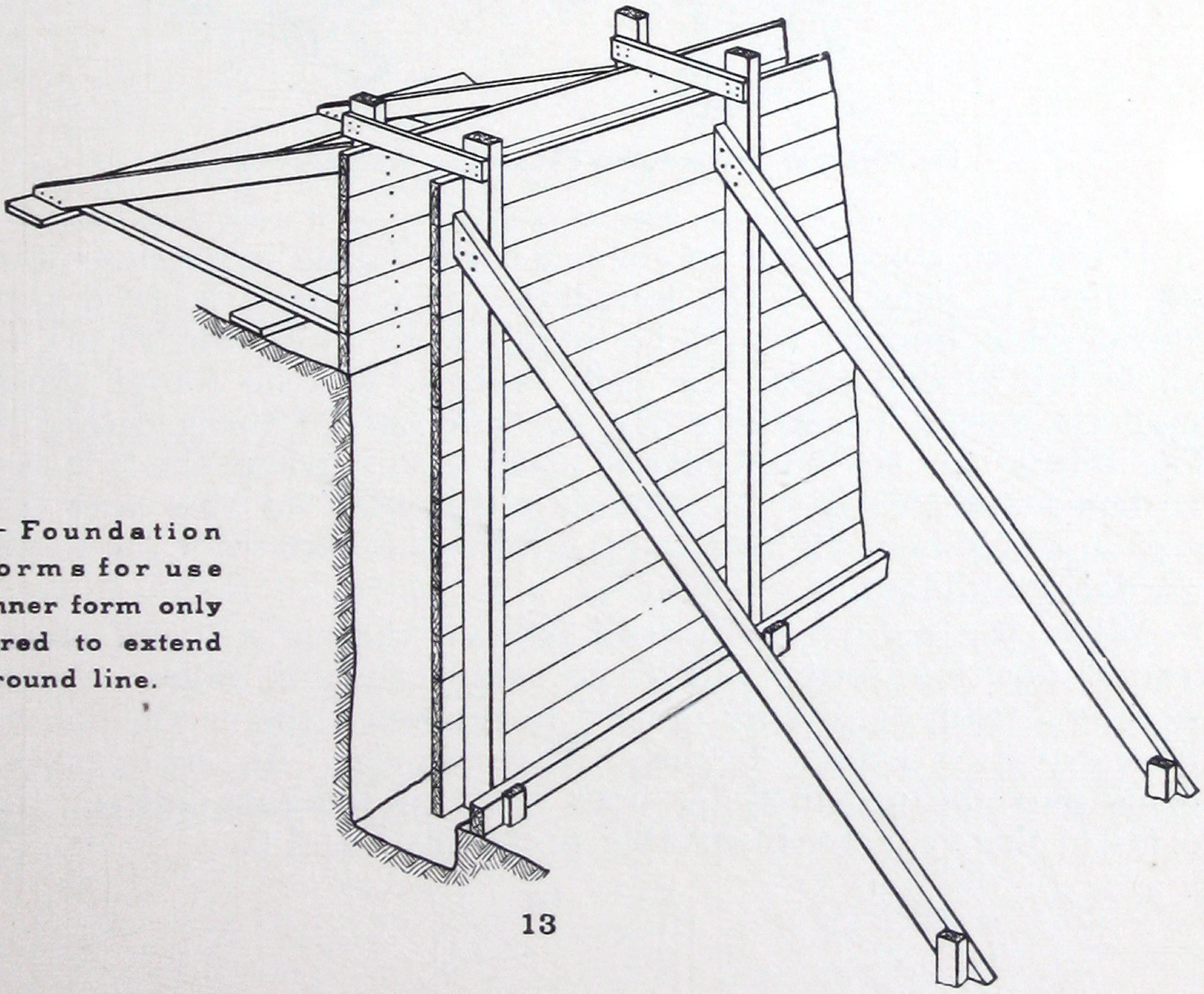


Fig. 3—Foundation Wall Forms for use where inner form only is required to extend below ground line.

cases, where it is not necessary to provide for a basement, an excavation may be made into which it is possible to place the concrete without the use of forms. However, if this method is used, great care must be taken to protect the edges and keep dirt out of the concrete. Where a basement is to be built in a stiff soil, the foundation may be built with the use of only one form, as shown in Fig. 3. It will be noted that all forms can be built of stock length lumber, with very little sawing, so that the lumber can be used later for other purposes. If a smooth face is wanted, dressed lumber should be used. It is customary where a building is to be of a material different from the foundation, such as cement plaster, frame and brick, to carry the foundation several feet above ground level. (This is not true, however, where the building is to be of concrete blocks.) A suitable type of form for carrying the foundation walls above ground is shown in Figure 4.

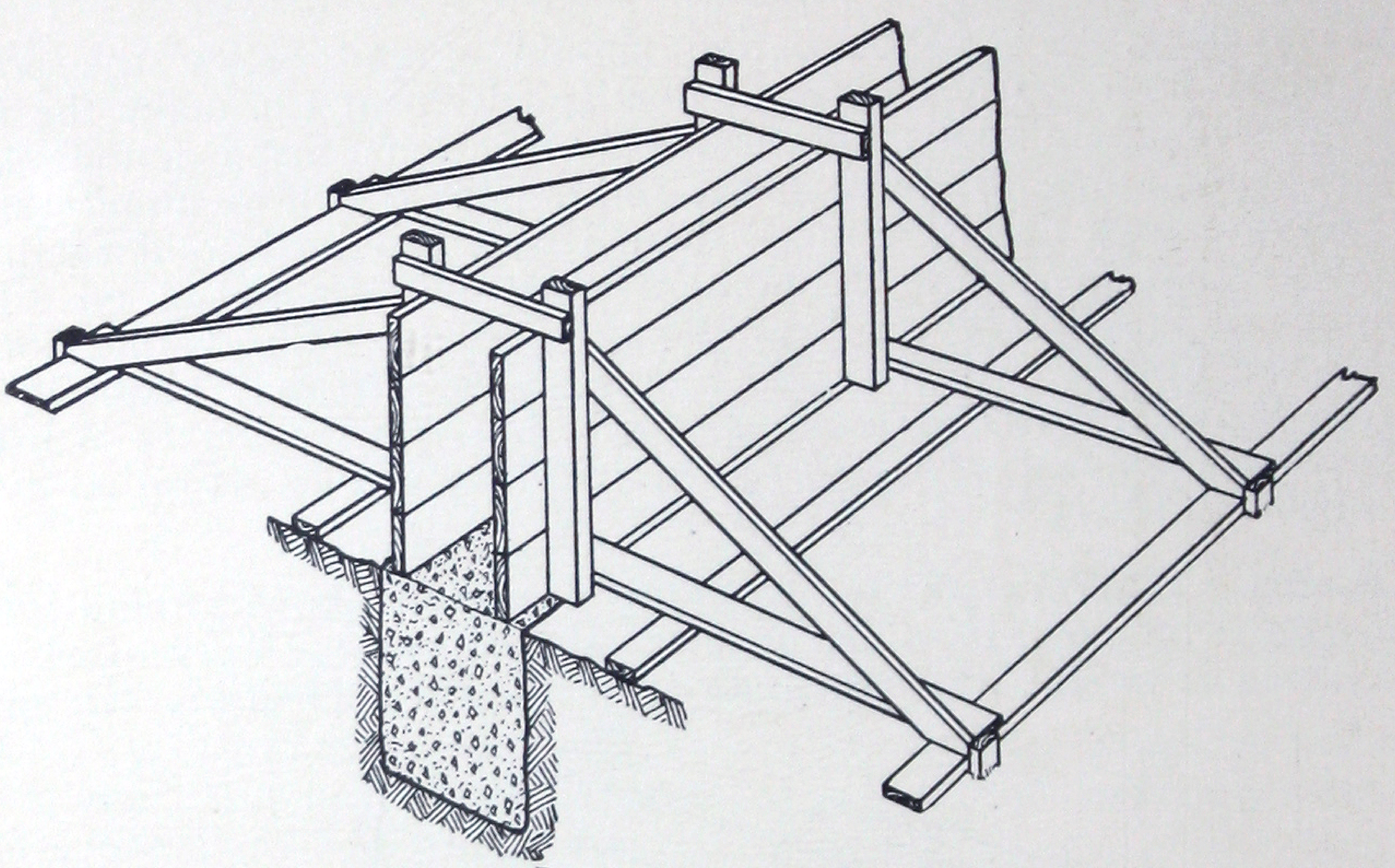


Fig. 4—Form for extending Foundation Wall above ground.

It is often convenient to construct the forms in sections and then put them in place. If the foundation is to be of large dimensions, considerable lumber would be required to build the forms for the whole job at one time. In such cases it will be found cheaper to build the forms in sections, the stock length of the sheeting boards. The forms can be removed and used again, when the concrete has hardened sufficiently. By planning the work in this way, a small amount of lumber will make all the forms necessary for the foundation of a large building.

When the nature of the soil is such that it will not stand in a vertical position, forms will be necessary on both sides. Sometimes, because a team or scraper is used in removing the earth, the walls of the excavation cannot be kept perpendicular. In such cases, also, forms must be provided for both sides of the foundation. Suitable forms of this type are illustrated in figures 5 and 6.

When erecting forms, one must bear in mind that they are to be removed, and when there is only a narrow space between the forms and the earth wall, provision should be made for their removal by some means which will result in the minimum of damage to the lumber. Very often, instead of bracing the outside form into the earth, it will be found better to wire it to the inside section of the form. The forms can then be kept in their correct relative position

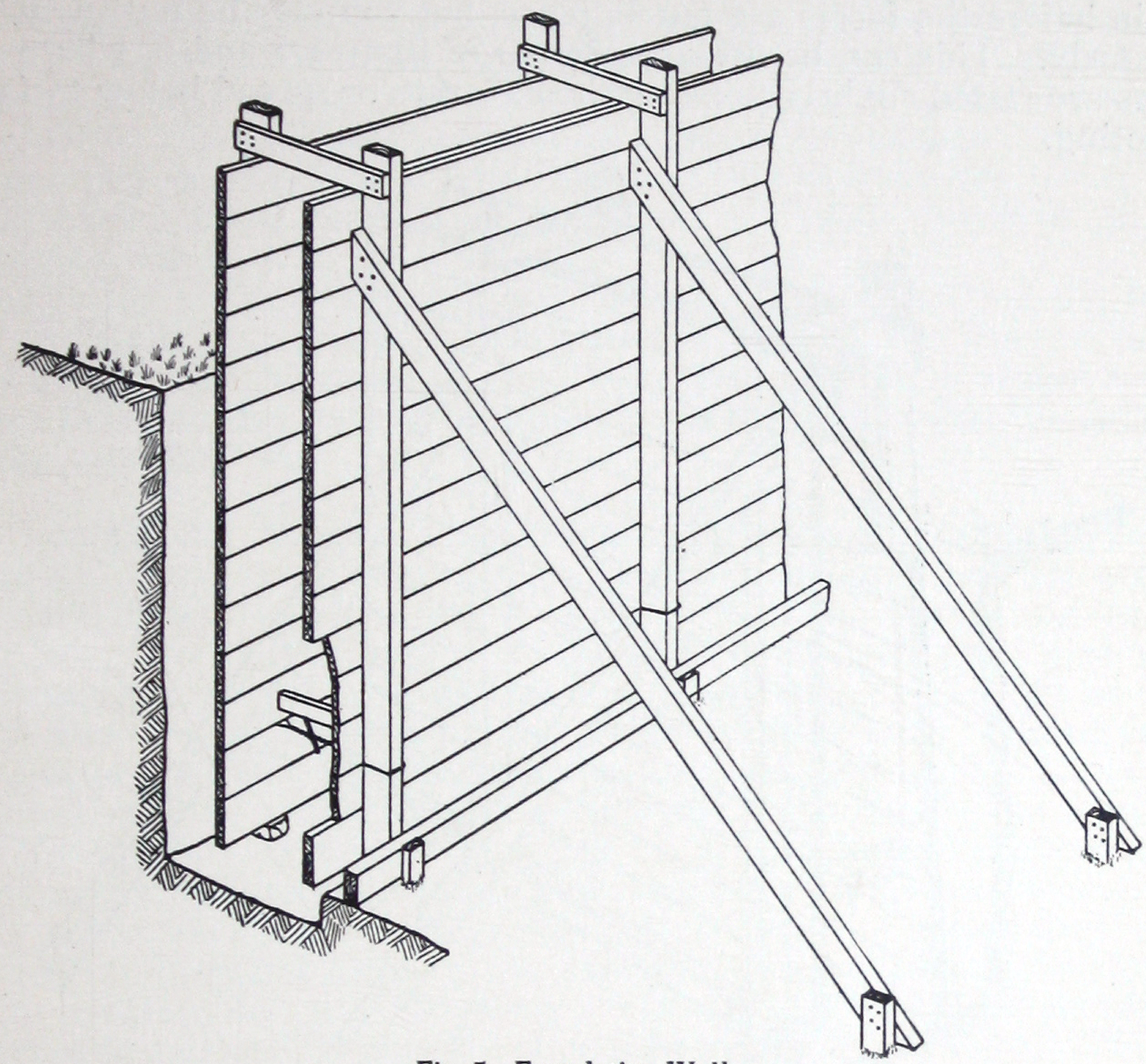


Fig. 5—Foundation Wall.
Forms for use where the ground is not firm enough to place concrete without forms.

by inserting spacing blocks of a length equal to the thickness of the wall or foundation between the forms. The wires should then be twisted with a nail or piece of iron, until the forms are drawn up tightly against the spacing blocks. If the wall is high, it may be necessary to insert additional wires and spacing blocks near the center of the uprights. As many sets of wires should be used as there are uprights, and the wires should be wound tightly around the uprights, as shown in figures 5 and 6. When 2-inch cross lumber is used, the braces can be set 3 feet apart; but care should be taken to see that they are securely braced, since the weight of the concrete in the forms causes a great pressure against the uprights and braces. The top of the forms can be held in place by means of cleats, as shown in figures 5 and 6.

Some means should be provided for removing the spacing blocks as the concreting progresses. This can be most conveniently done by attaching a wire to the block, by which it can be withdrawn as soon as the concrete reaches the level of the block.

Footings are generally used as a base for the foundation proper. A footing is usually about 4 to 8 inches thick and should be twice the width of the lower end of the foundation wall. They are often put in before the forms are put in place, but can also be put in simultaneously. This can be done as shown in figures 5 and 6, where the forms are raised slightly to allow the concrete to spread below to form a footing.

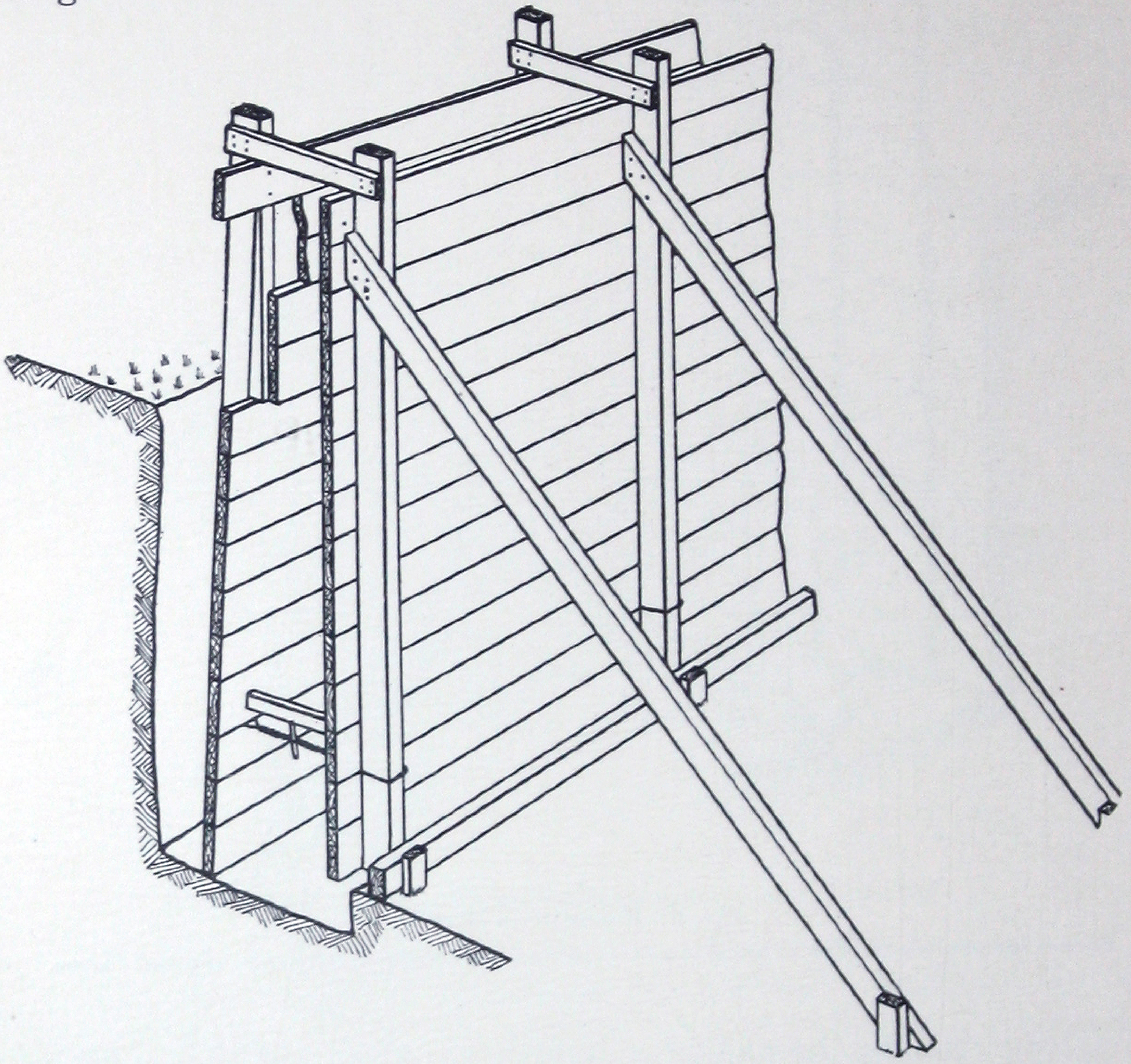


Fig. 6—Foundation Wall. Forms showing inside form raised to provide a spread footing.

When form boards have been used before, care must be taken to see that all old concrete is well cleaned from the faces and edges. The forms can be protected and the concrete prevented from sticking to them by painting the faces with whitewash. Crude oil or a mixture of equal parts of linseed oil and kerosene can also be used successfully.

Forms should be as nearly water-tight as possible. If they are not, the water in the concrete will escape and carry with it a considerable quantity of cement. Cracks between the boards often leave room for the mortar to squeeze through, thereby producing fins or unsightly lines on the face of the wall. Sharp corners should be avoided by the use of fillets, since it is often difficult to fill corners with concrete, especially when coarse material is used.

Concreting the Foundation. Concrete for foundations is usually made fairly wet—just wet enough so that it will flow in the forms. It is generally not necessary to tamp the concrete, but great care should be exercised to see that no air spaces remain in the concrete after it has been placed in the forms. This can be prevented by stirring the concrete with a pole just after it is placed. The stirring should be kept up during the entire process of concreting.

A suitable mixture for most foundations is one part of cement to six of gravel, or when sand and crushed stone are used; 1 part cement, 3 of sand and 5 of stone. These mixtures will make a good foundation for buildings of small or even moderate size. Where the foundation is to be for a large building, the proportions to be used will depend upon many local conditions and upon the type of construction used.

The top of the foundation should be leveled off, so that the forms for the walls may be conveniently placed thereon, but the top should not be troweled, as troweling makes it more difficult to secure a good bond between the foundation and the wall proper, when the latter is to be continued up.

Joining Old Work. Very often a foundation cannot be poured entirely in one day. And also, where all the forms are not erected at once, it will be necessary to pour part of the foundation on one day, and part on the next. When such is the case, great care must be exercised to get a good bond or joint between the old and the new concrete. Unless precautions are taken, clearly defined joints or cracks are likely to develop along the weakened bond. Horizontal joints should be avoided wherever possible. Frequently the work can be divided into sections which can be poured without interruption, thus avoiding horizontal joints and creating vertical ones where they will not weaken the structure nor detract from its appearance. The Universal Portland Cement Co. recommends the joining of old and new concrete by the following methods: "The forms should be erected in sections, or a board should be set up in the form, making a complete partition. So that the sections of the wall will be keyed into each other, a groove should be formed in both ends of the first section, and thereafter in one end of each section. Such a groove can be made as shown in figure 7, by placing a 2 x 4 vertically against the wall or partition, in the form. Previous to placing, the edge of the 2 x 4 should be dressed, so as to make it possible to remove it without destroying or marring the groove. In the course of construction, the next section will be concreted against the first and the groove will be filled with concrete, thus keying the two sections together. In building up a wall, the concrete in the section under construction should be kept at the same level as far as possible. If for any reason fresh concrete is to be placed on concrete even partially hardened, the surface to be built upon should be thoroughly drenched, and then covered with a

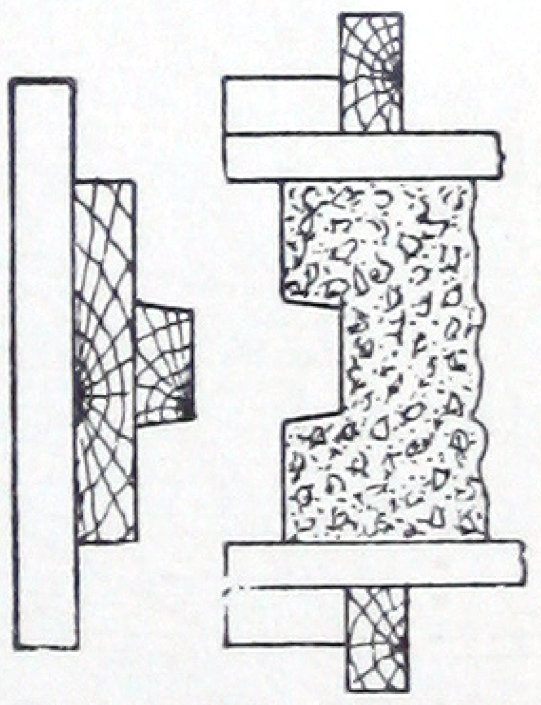


Fig. 7—Method of joining foundation walls where it is necessary to leave an expansion joint or where concreting has been discontinued for any reason.

grout made by mixing cement with water to the consistency of cream, immediately before it shows any signs of drying. The amount of water that will be required in dampening the old concrete will depend upon a number of conditions, but its tendency to absorb water must be satisfied; otherwise the water will be absorbed from the grout which will make it worthless, and defeat the object of its use. All foreign matter, such as loose sand, straw, chaff, leaves, etc., must be removed from hardened or partially hardened concrete before work is resumed."

Removing the Forms. It is practically impossible to lay down any definite rule for the removal of forms from concrete work. In general it may be stated that the forms can be removed when the concrete has hardened sufficiently to retain its shape and permit of the continuing of the work without damage to the concrete in place. Removing the forms too soon leaves the concrete without proper protection from the weather, as well as from loads or stresses to which the concrete may be subjected. In cold weather the forms must be left on longer than in warm weather, since the concrete hardens more slowly in lower temperatures. The forms should be oiled or whitewashed, as suggested on page 15, so as to facilitate the work of removing them, as well as to insure the least amount of damage to the concrete during their removal. As a general rule for ordinary cases, it may be stated that forms must be left in place for 3 or 4 weeks if there is earth or water pressure against the concrete. With sidewalks and driveways not subject to load, 24 hours is sufficient, but they should not be opened to traffic for three or four days, or until hardened completely. Forms should not be removed from reinforced structures until the concrete has seasoned (7 to 10 days), and they should not be loaded for several weeks.

CONCRETE WALLS.

There are several types of concrete walls used, each type having its particular advantage for certain kinds of work, while all possess in common the general advantages of concrete construction. Some forms of concrete walls are: Monolithic walls, concrete block walls built of either hollow or solid blocks, and concrete tile walls. Another type of wall is that constructed of concrete posts or columns, and slabs cast in forms on the ground and afterwards assembled. Then there is the plaster wall, built of three or more coats of cement plaster applied to metal lath.

Where appearance is not of special importance, other conditions being equal, the monolithic wall will be found the most serviceable. For retaining walls it is the only construction that can be used to advantage. A monolithic wall is a solid concrete wall, built either single, or double with an air space. There is no object in using the double monolithic type, except where it is used as the wall of a building. For ordinary outdoor service, the single monolithic wall is the most serviceable, and we will confine our discussion to this type of wall.

Forms. There are two general types of forms which can be used

for the construction of monolithic walls—wood forms built for an entire section of the wall before the concreting begins, and wood or metal portable forms which are erected in sections as the work progresses. For work to be done by persons of limited experience in concrete construction, we recommend the use of the former type, since the use of the latter type requires the greatest care in properly joining the horizontal sections.

A suitable type of wall form is illustrated in figure 8. The uprights are called "studs"; the horizontally placed boards are called "facing," while the diagonally placed pieces are called "braces." The uprights should be 2 x 4 inch lumber—also the braces. White pine is the best lumber for the facing, but spruce, fir and Norway pine may be used. Two-inch stuff is recommended, since lighter material is more difficult to keep in alignment and requires closer spacing for the studding. When 2-inch stuff is used, the studs can be 3 feet apart for all ordinary walls. The forms should be so planned that the lumber can be used again. The facing need be nailed only slightly to the studding,

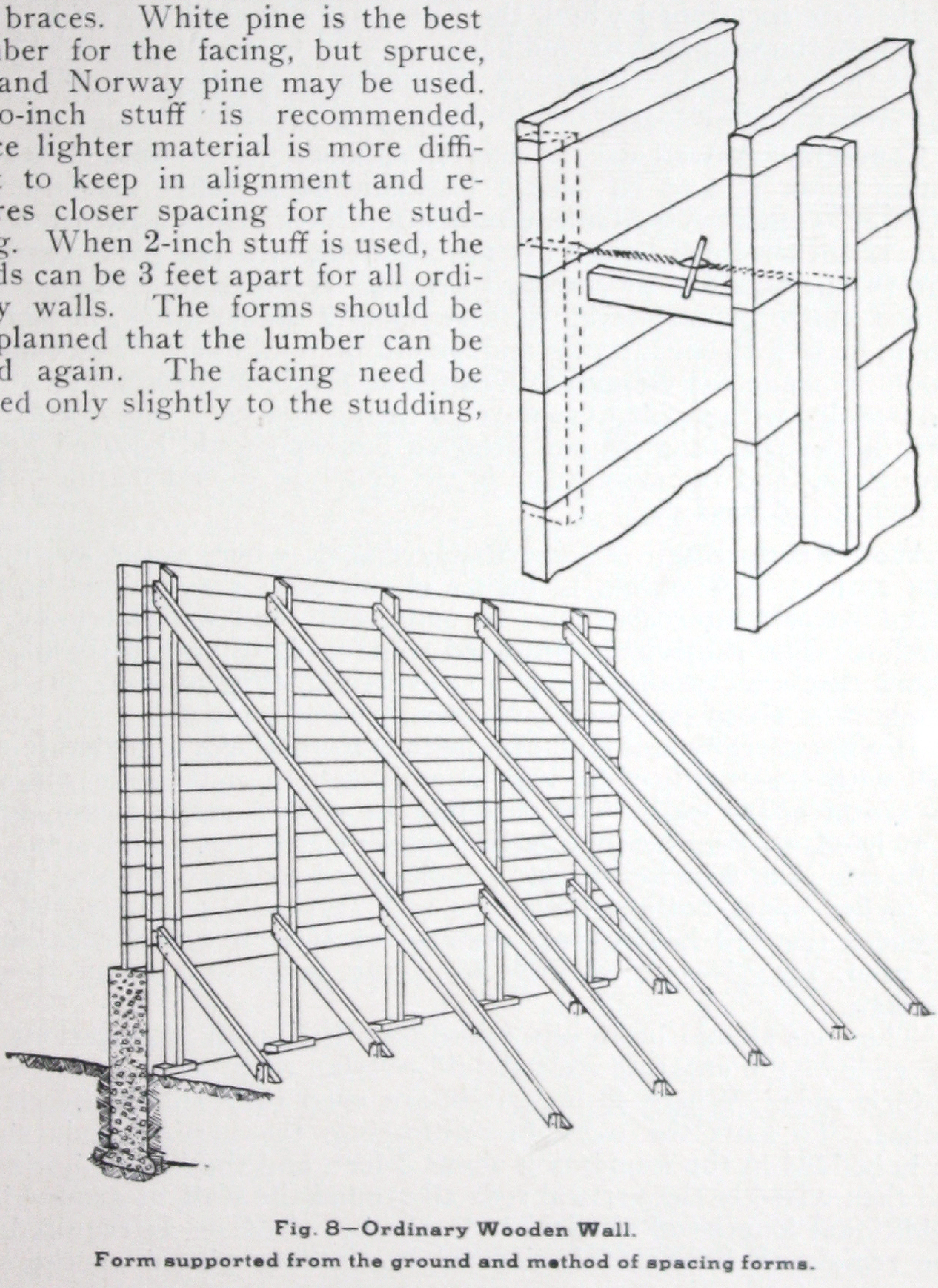


Fig. 8—Ordinary Wooden Wall.
Form supported from the ground and method of spacing forms.

since the concrete will hold the boards in place against the studs. The forms should be kept at a uniform thickness by the use of wire and spacing blocks, as explained on page 15. The same care should be execised for wall forms, as in the case of foundations, in making the forms water-tight (see page 16), and in cleaning the boards (see page 16). The boards should be whitewashed or oiled, to facilitate their easy removal, as explained on page 16. The same method for joining sections should be used for walls as for foundations (see page 17), and no sections should be longer than 30 feet. The forms should not be removed until the concrete is fairly well hardened (see page 18). A few hours gained in time will not compensate for the loss occasioned where the forms are removed too soon.

Where the wall is to extend below ground level, care must be taken to get the proper excavation. A discussion of excavations and forms for below ground level will be found on pages 13 and 14.

Concrete. A wall usually has to support the ground, instead of resting upon it, and so should be made of a richer mixture than floors or walks. A suitable mixture for most walls where not less than 12 inches thick is one (1) part cement, two (2) parts sand and four (4) parts stone or screened gravel. If the wall is higher than 12 feet above ground level, or less than 12 inches thick, or both, it should be of a richer mixture and should be reinforced. The concrete should be made wet enough to flow in the forms, and should be stirred and puddled with a pole to remove all the air spaces. Where a smooth finish is desired, tongued and grooved lumber should be used for the form facing and the stone used in the concrete should be fine—about ½ inch, hand passed.

Wall Reinforcing. As previously stated, where walls are higher than 12 feet, or less than 12 inches in thickness they should be reinforced to prevent cracks due to settlement and expansion or contraction. The subject of reinforced concrete is of such a complicated nature that we cannot attempt to cover it in this booklet, but a few simple facts about reinforcing walls may be of some use.

It will generally be found satisfactory to reinforce a moderate sized wall with a network of horizontal and vertical metal rods, placed in the center of the wall. The rods may be of any shape, round, square or twisted, so long as they have sufficient cross sectional area. For walls less than 8 inches thick, ⅜-inch round rods are suitable, spaced 24 inches apart both horizontally and vertically. Where the wall is wider than 10 inches, two systems of ⅜-inch round rods should be used, placed about 1 inch from the inner and outer faces of the wall.

The rods should be rigidly wired together at all intersections, and the ends of the separate rods should overlap each other 24 inches for ⅜-inch rods. Where ½-inch rods are used they should overlap 32 inches. To start the work of reinforcing, the vertical rods should be imbedded in the foundation about 2 feet, and the lowest horizontal rod then wired to the vertical rods all around the wall, at ground level. Additional lengths of vertical rods can be wired on as required, and the remaining bands of horizontal reinforcing placed as the work

progresses. The rods should be placed before the concrete reaches the level of the rods, and the concrete should be thoroughly puddled to insure a compact mass around the reinforcing rods. At corners in the wall, special reinforcing must be supplied. A very simple method of reinforcing corners is shown in figure 9. It is easy to figure out fairly accurately the number of reinforcing rods required for a concrete wall. Where the rods are spaced, as explained above—every 24 inches horizontally and vertically—the number of vertical rods required will be one-half the length of the wall in feet. The number of horizontal rods will be one-half the height of the wall in feet, multiplied by the number of rods used in one course of horizontal reinforcing. One corner requires about 2½ extra feet of extra rod per foot in height. Reinforcing rods are sold by the pound and generally come in lengths from 12 to 30 feet.*

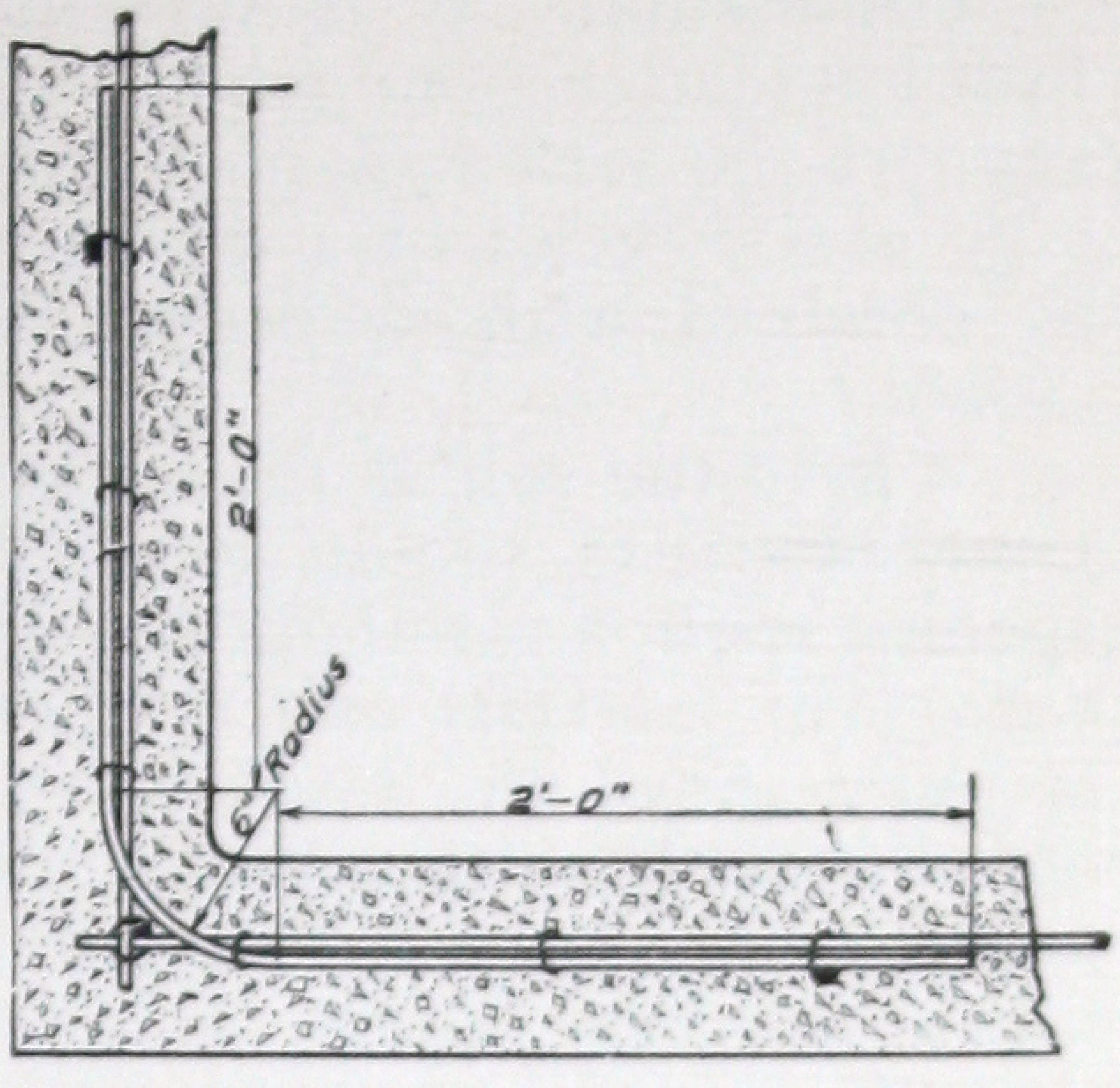


Fig. 9—Method of reinforcing corners for Monolithic Wall.

CONCRETE SIDEWALKS.

Concrete is now accepted as the ideal material for sidewalk construction. The sidewalk in most general use now is the two-course walk with the smooth steel-trowel finished surface. By two-course we mean a base of rough concrete, covered with a fine mixture of cement and sand for a wearing surface. We regret this prevalence of the two-course finished walk, since a glassy finish is not safe for winter use and not desirable from an artistic standpoint. All modern architects feature the one-course walk of rough concrete, with a rough cast surface obtained by the use of a wood trowel. When the concrete is mixed wet enough, the thinner and richer portion will rise to the surface in sufficient quantity so that it can be nicely troweled into a smooth, but not glassy, surface. The one-course walk is uniform in character, the entire mass being wearing surface, and can be laid more cheaply than the two-course walk. Below is shown the comparison of the two constructions based on 100 sq. ft. of surface:

Type	Mixture	Bbls. Cement	Cu. Yds. Sand	Cu. Yds. Stone	Total Cost Material
5 -in. 2 Course	1:2½:5 Base 1:1½: Top	2.52	.80	1.21	6.79
4½-in. 1 Course	1:2 :3	2.42	.73	1.08	6.16

Table by Universal Portland Cement Co.

Basis—Cement at $1.50 bbl.
Sand at $1.25 cu. yd.
Gravel at $1.50 cu. yd.

*FOOT-NOTE: Method recommended by the Universal Portland Cement Co. for reinforcing walls of small concrete farm buildings.

Foundation. It is very important that a sidewalk be given a firm foundation—one which will, at all times and under all conditions, support the walk. A poor sub-base or an improperly constructed fill may easily result in a defective walk, and when a perfect walk can be obtained with so little additional effort, such failures are inexcusable.

Where the soil at the excavated grade is firm and solid, it will be unnecessary to use an artificially prepared sub-base. But if soft or spongy spots are found, they should be removed, and the holes filled with firm material and tamped into a solid mass. Often the walk is built above the level of the surrounding ground, to preserve a definite grade with adjoining walks. In such a case a fill must be made, and great care should be exercised in its preparation. The filling material should be layed in layers about 6 inches thick and then thoroughly tamped. The fill can then be further compacted by sprinkling and then retamping. The sub-base of cinders or gravel should be placed on the fill, as shown in figure 10, and should also

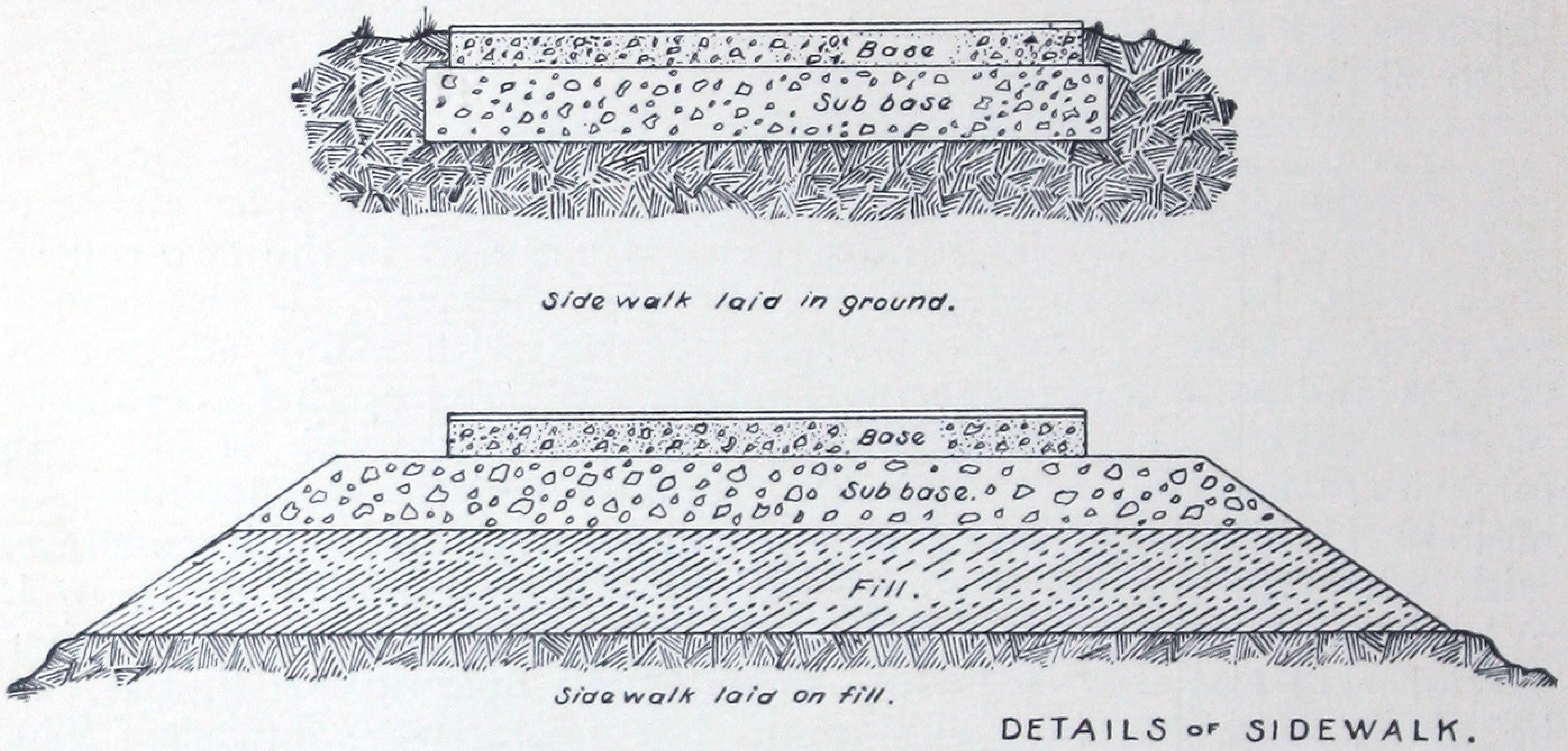


Fig. 10—Detail of sidewalk.

be thoroughly compacted by sprinkling and tamping. It should be given a pitch of ¼ inch to the foot toward the gutter, so as to facilitate the drainage.

Forms. Two-inch lumber is in general use for sidewalk forms. There are several types of metal sidewalk forms, which when the work is in sufficient quantity are both convenient and economical for use in sidewalk construction. For forming curves, thinner material must be used, which can be easily bent into form. A strip of metal or thin wood can be used in this connection, but care must be taken to drive enough stakes to hold the form in position against the tamping of the concrete.

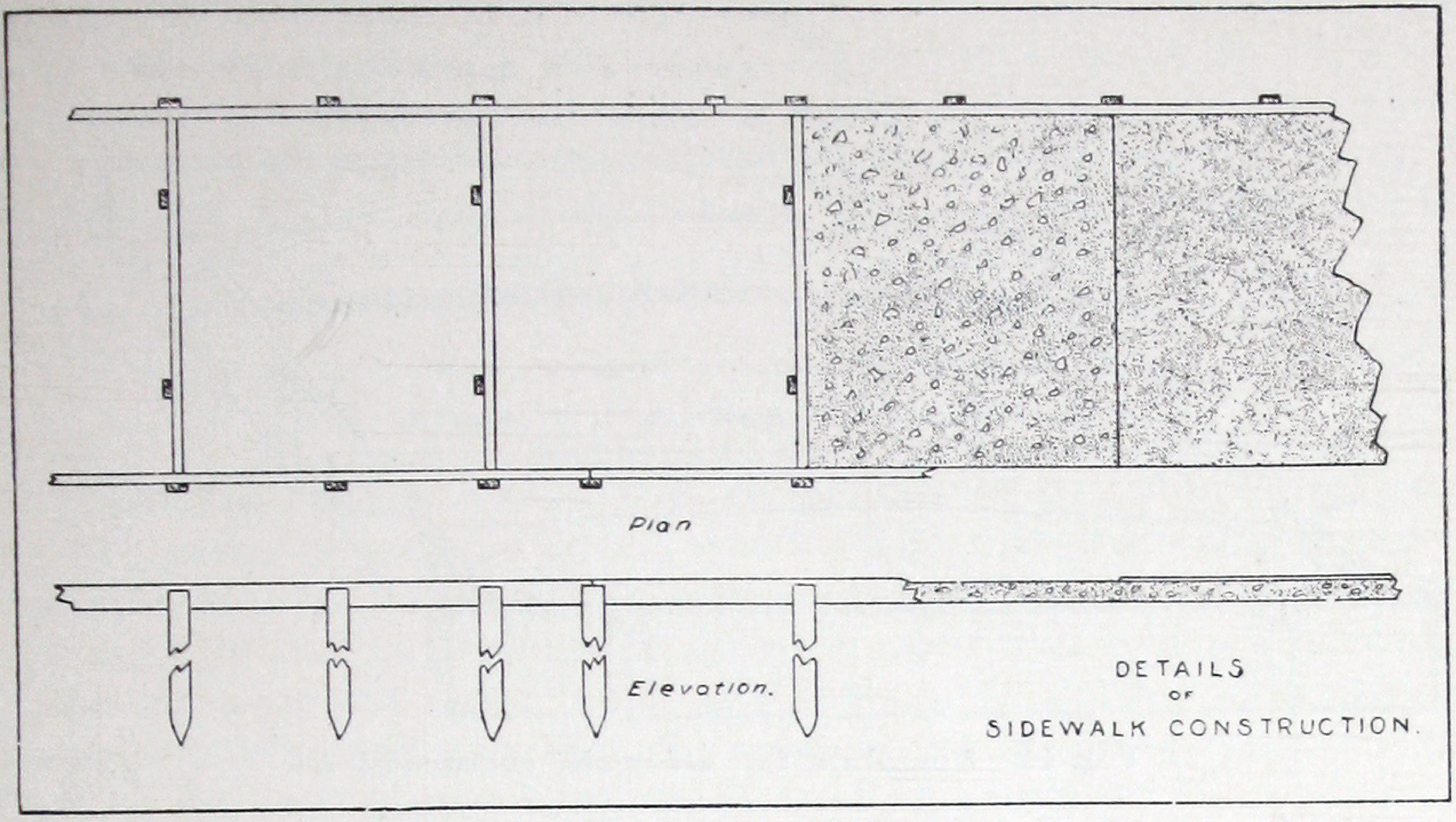


Fig. 11—Forms for sidewalk construction.

A sidewalk should be provided with joints to prevent injury to the walk from the rise or fall of the earth underneath. The most perfect joint can be made by the use of a metal cross form about 1/8 inch thick, and of a height and width equal to that of the walk. However, a joint can be secured, when using wood cross forms by tamping the concrete against the cross form of one slab, as shown in figure 11. The cross-piece should then be removed and the next slab poured.

The side forms (usually 2″ x 4″, or 2″ x 6″) should be perfectly aligned and securely staked. The side form should then be marked at the points where the cross form is to be placed, since the divisions will be obscured later by the top-dressing. The divisions of the top-dressing should be made at the same place as those in the base. The divisions should be so placed that no slab contains more than 36 square feet, and the length of the slab ought not to exceed one and one-half times the width.

Thickness. Sidewalks, where the traffic is very heavy, should be about 6 inches thick. Where the traffic is lighter, 5 inches is thick enough for a two-course walk, and 4½ inches for the one-course type. Where the traffic is heavy, the top coat for a two-course walk should be one inch thick, while ¾ inch is sufficient for walks of lighter traffic.

Drainage. For ordinary purposes, suitable drainage can be obtained by tilting the walk slightly—¼ inch to the foot—toward the gutter. To accomplish this, the form nearest the street should be placed slightly below the inside form. Another very satisfactory method of draining walks, is to give the top a curved surface, making it highest in the center. This process is called crowning the surface, and is accomplished by using a template or strike board, as shown in figure 12.

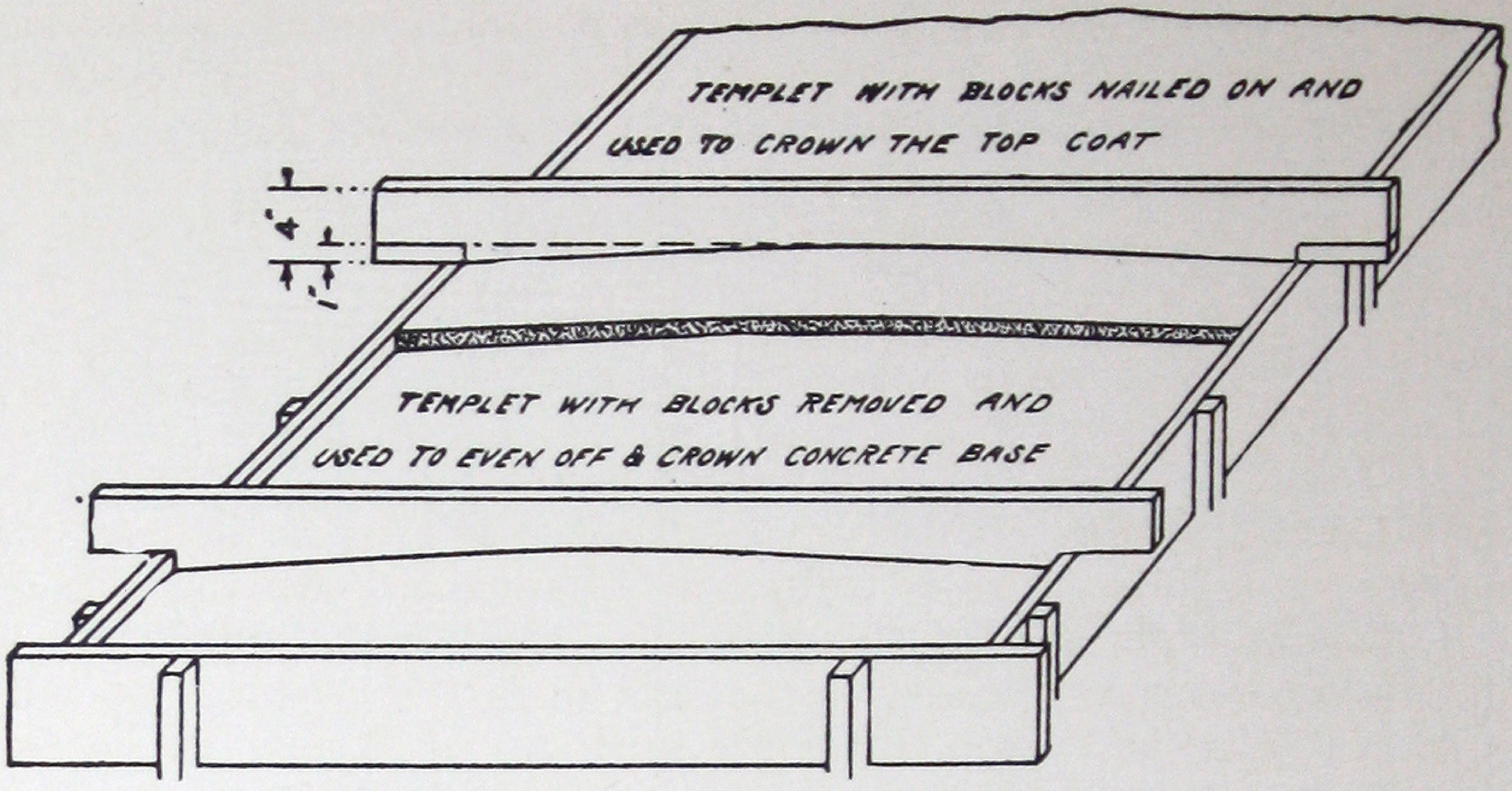


Fig. 12—Template for sidewalk construction

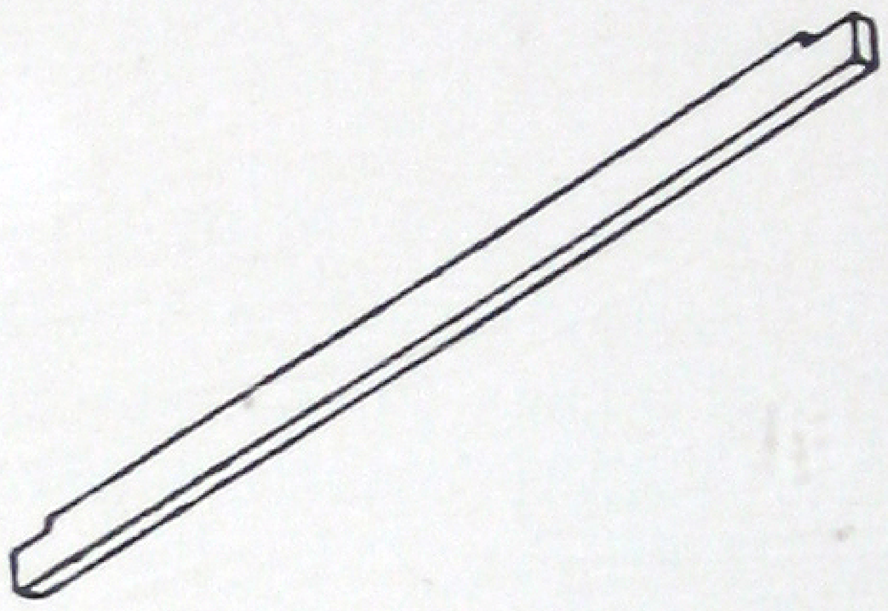


Fig. 13—Strike Board used for gauging base and striking top.

A suitable strike board and base gauge is shown in figure 13.

Proportions. The proportions to be used for sidewalk work is subject to some allowable variation, but for most two-course walks a suitable mixture for the base is one part cement, to three parts fine sand, to five parts stone. The top dressing should not be leaner than one part cement to two parts screened sand. The base should be made just wet enough so that moisture appears at the surface after tamping. The top mixture should be wet enough to spread easily under the template or strike board, but should not be so wet as to flow.

Placing the Concrete. When the side forms and cross forms have been placed the concreting can be begun, starting at one end and progressing toward the other. One section should be filled first and leveled off with the strike board, any excess concrete being scraped over into the next section. The concrete should then be tamped, and the shrinkage obtained thereby will leave room for the top-dressing. The surface of the concrete can then be gauged by using a strike board, such as is shown in figure 13, in which the ends are notched out to the proper thickness. This side can be used for the gauge, and the other side for leveling the concrete.

When one slab is finished the cross form can be removed and the next slab placed, but care must be taken not to break down the vertical edge of the first slab, as this edge serves as the joint. If metal cross forms are used they can be left in until ready for the top-dressing. They should then be carefully extracted and the joint filled with sand.

As soon as possible after tamping the base, the top-dressing or mortar should be put on and leveled off with the strike, using the side forms as guides. When the mortar has stood for a short while,

it should be smoothed with a wooden float and then troweled until a smooth-finished surface is obtained. The joints can then be cut by cutting through with a pointed trowel, using the strike as a straight-edge. The joint is then finished by running the groover along the joint without using the straight-edge, and the edger along the side forms to leave the work with an unmarred surface.

Illustrations of these various forms of finishing tools are given in figure 15, page 27. All holes or indentations left in the surface should be filled and smoothed with the wooden float.

One-Course Walks. For the construction of one-course walks much the same procedure is followed. The forms are the same and the mixing and placing of the concrete goes on in much the same manner. The concrete must be heaped up slightly when placed, so that the tamping will just bring the surface to grade. Top-dressing is dispensed with entirely, but the mix of the concrete must be made wetter, so that the surface can be floated and finished.

Joining Old Work. The top-dressing in two-course walks must be placed on the base while the latter is still wet and before it has started to harden. This is necessary to secure a good bond between the two. When a walk cannot be finished in one day, whatever portion of it is done the first day must be finished complete with the top-dressing, finishing, grooving and edging. Each slab must be finished complete, no portion of a slab being left over until the next day. A fractional part of a slab should never be left over upon suspending work even for the noon hour. The concrete should be tamped against the cross form, so that when work is resumed it will start from a vertical joint between abutting slabs.

Driveway-Crossings. Wherever a walk is crossed by a driveway, the thickness of the base should be increased at least two inches and the top should be at least 1¼ inches in thickness. Where a walk is of considerable length, a half-inch expansion joint should be left every 50 lineal feet. This can be done by placing a half-inch cross-piece of wood between the side forms and at right angles to them, and allowing it to remain there until the walk has hardened. It can then be removed and the space left filled with some suitable material. Sand can be used as a filler for the joint, but tar is recommended as being the best material for this purpose.

CONCRETE FLOORS.

Most people are building their floors of concrete, and there are many reasons why they should. From the standpoint of convenience, sanitation and ultimate cost, the concrete floor is without an equal.

Foundation. As in the case of sidewalks, the floor must be built on a firm foundation. When the soil is hard and compact, and has good natural drainage, a sub-base is unnecessary. But if the soil is heavy and holds water, a sub-base of cinders or gravel is advisable. In case you are in doubt, put in a sub-base and be safe. The sub-base

should be about 8 inches thick and should be thoroughly tamped and sprinkled to make it as compact as possible.

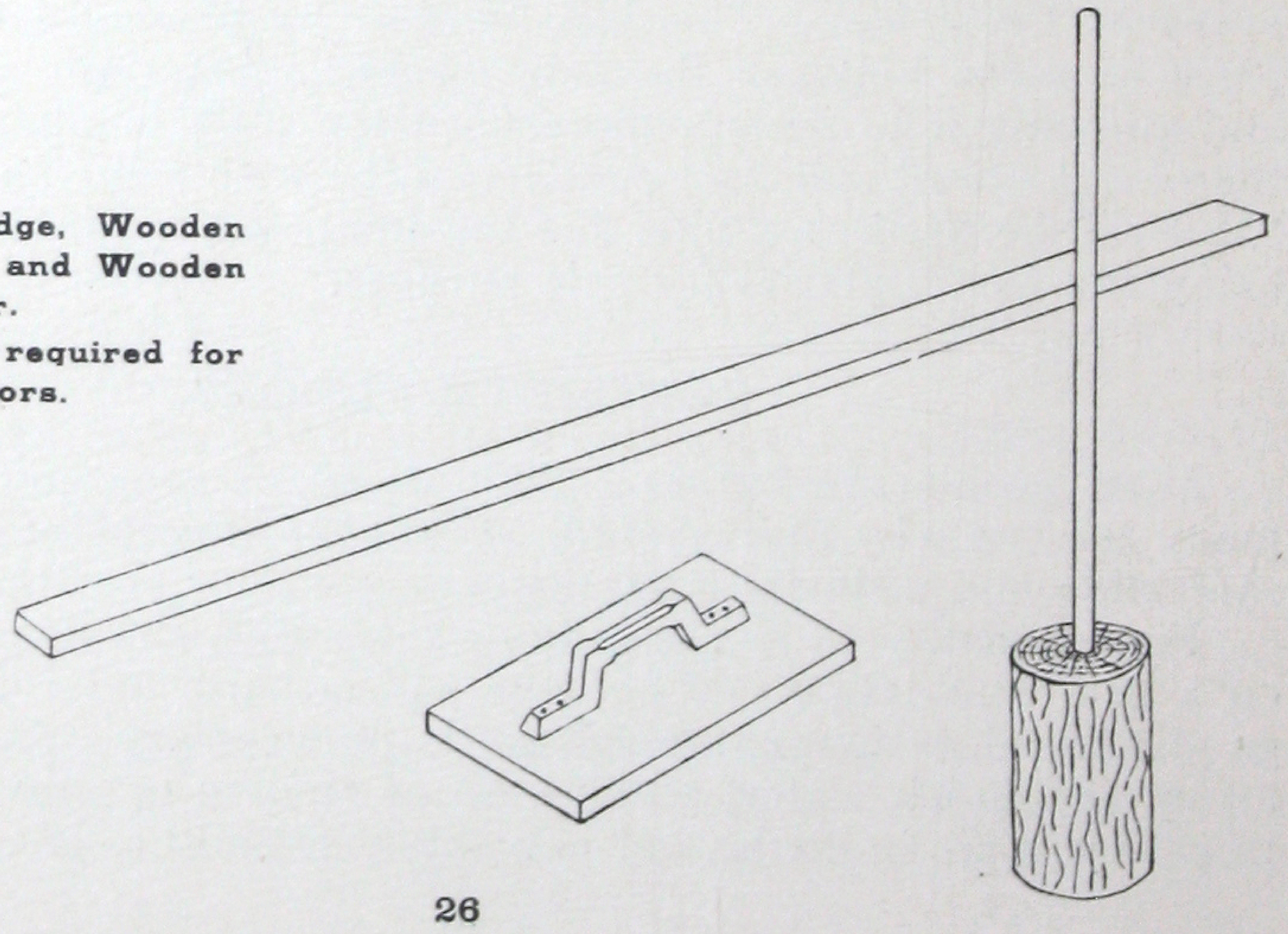
Forms. Where forms are necessary for the edges of the floor, 2-inch lumber should be used, since it can more easily be kept in alignment and requires less staking. Floors of ordinary-sized buildings are generally made 4 to 6 inches thick, for which 2 x 4 inch or 2 x 6 inch form lumber should be used.

Concrete. For the concrete base of floors in general, a suitable mixture is one (1) part cement, two and one-half (2½) parts sand and four (4) parts stone or screened gravel. This, of course, applies only to floors resting on the ground. Suspended floors require a richer mix and must be reinforced. Sufficient water should be used in the concrete to produce a mixture which, when placed and tamped, will readily show moisture on the surface. The concrete should be placed and tamped as quickly after mixing as possible, and under no circumstances should be allowed to stand longer than half an hour before placing.

Top Coat. The concrete base is usually covered with a finish coat of cement mortar, ¾ inch to 1 inch in thickness, although the surface coat is often unnecessary, especially where a smooth finish is not desired. If not to be given a mortar coat, the surface of the base should be finished with a wood trowel, but the concrete must be made a little wetter, so as to allow enough fine material to come to the top to permit of a smooth finish.

When a mortar coat is desirable, it should be placed directly upon the tamped base while the latter is still wet and before it has hardened. While the base is exposed, great care must be exercised to keep sand, dust, clay or other foreign matter from getting onto the surface, since such material invariably prevents a good bond between the top and the base. No leaner mix than 1 part cement to 2 parts screened sand should be used for the top coat; and sufficient water should be

Fig. 14—Straightedge, Wooden Finishing Trowel and Wooden Tamper.
Home made tools required for laying floors.



used so that it will spread easily. The mortar should be placed as quickly after mixing as possible.

A straight-edge can be used to spread the mortar to a true grade, and the surface should then be smoothened with a wood trowel, great care being taken that the surface contains no dips nor hollows.

Drainage. For the purpose of securing good drainage, the floor should be made to slope toward some suitable point; a quarter inch to the foot is sufficient pitch to insure good drainage. The slope may be to a drain in the center of the floor, or to a point from whence it is conducted to an outlet by a small gutter running along the floor.

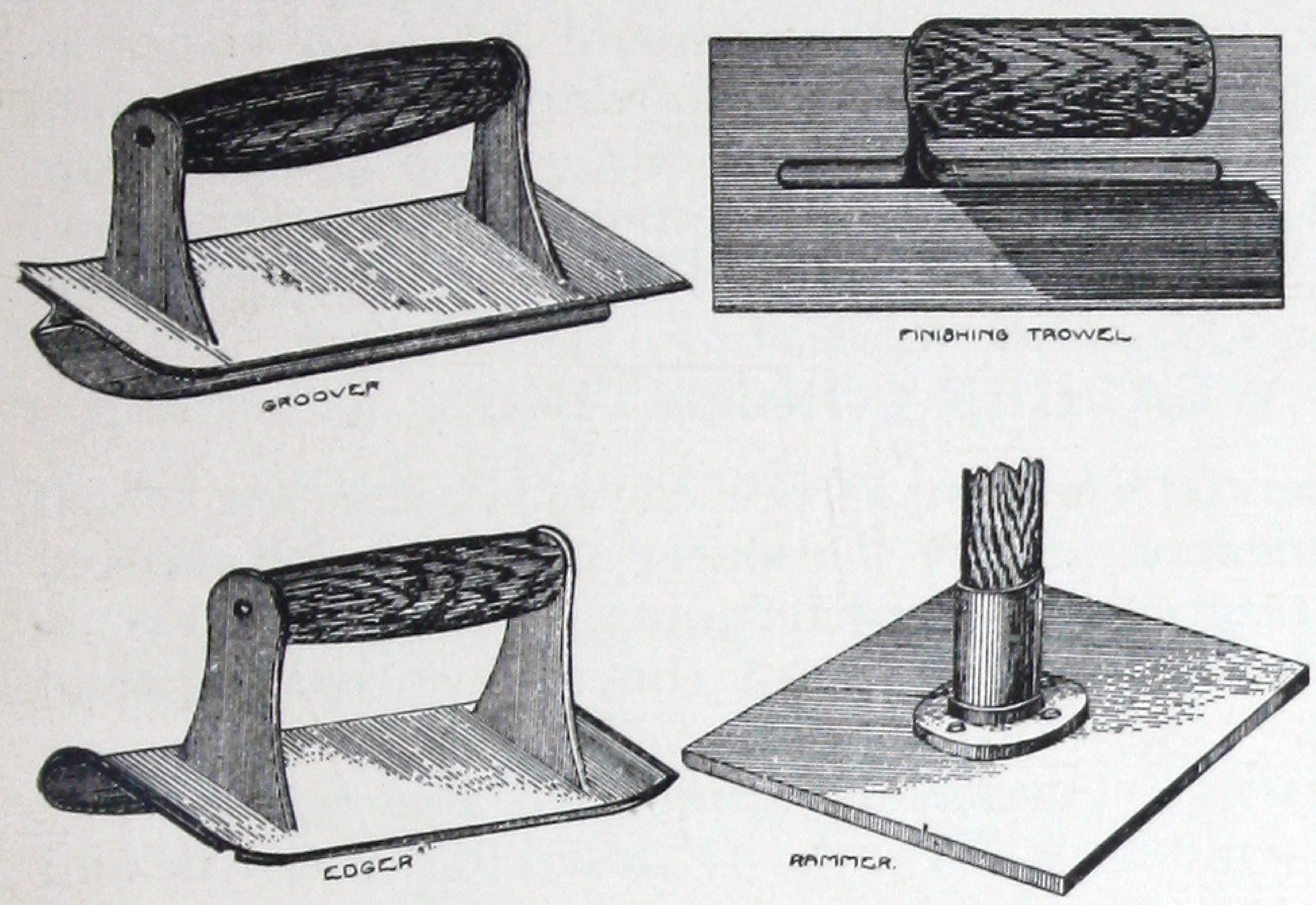


Fig. 15—Steel Rammer, Finishing Trowel, Groover and Edger, for finishing floors and sidewalks.

Marking. After the floor has been troweled and graded, the surface is usually marked off into blocks, not larger than 5 feet in either dimension. The marks can be first cut by the point of a trowel, using a straight-edge to insure a straight line, and then worked down with a groover. The outside edges of the floor are then finished with the edger. (See figures 14 and 15.)

Protection. Where the floor is outdoors, it should be protected when finished against rain, frost and over-rapid drying. When the surface is sufficiently hard, it is customary to cover the floor with fine sand and then sprinkle it now and then until it has thoroughly hardened.

Where a Smith Hand Mixer is used, a great saving in time and labor can be accomplished by running the mixer right onto the sub-base and discharging the concrete directly into place. By so doing, the necessity of wheeling the mixed concrete is entirely eliminated.

CONCRETE DRIVEWAYS.

The construction of concrete driveways is much the same as that of sidewalks and floors. The same precautions must be taken as to the sub-base and foundation, and where an artificial sub-base of cinders or gravel is necessary it should be six inches thick. The concrete should be at least 5 inches thick and should be of a mixture no leaner than one (1) part cement, two (2) parts sand and four (4) parts stone or screened gravel. If a two-course driveway is used

the top should be at least 1 to 1¼ inches thick, and should consist of a mixture containing one (1) part of cement to two (2) parts screened sand. Where a driveway is to be used by heavy traffic, a one-course construction is recommended as being the most substantial and best suited for heavy traffic. The driveway should be marked in squares or oblongs as explained on page 27, and where of considerable size, should be equipped with expansion joints. The lateral drainage should be toward the center and the longitudinal drainage toward the street. Where the driveway is used considerably for horses, it is customary to make the surface with lateral grooves, to give the horses a better footing. The grooves should be placed from 12 to 16 inches apart, and the grooving should be done after the surface is finished and hardened slightly. Grooving the surface would not be necessary where the driveway is of one course construction. The instructions previously given for the construction of walks and floors should be followed in the construction of the concrete driveway.

COLD WEATHER CONCRETING.

As water is an essential element in the chemical reaction which produces Portland Cement concrete, the water must not be allowed to freeze. Low temperatures stop the hardening of concrete. Freezing has caused more failures of reinforced concrete structures than any other single cause.

Work can be successfully carried on during freezing weather by either or both of two methods: First, by lowering the freezing point of the concrete, this method being effective for temperatures not too far below freezing; and Second, by heating the concrete materials and then protecting the work until it has had a chance to harden. The simplest and cheapest way to lower the temperature of the concrete is to mix salt with it, as follows: For each degree F. below 32 degrees, one part of salt by weight to every 100 parts of water. More than ten per cent of salt cannot be considered safe. As 10 per cent salt is not effective below 22 degrees F, this method is not advisable for lower temperatures. In cases where the appearance of the surface is a factor, salt should not be used, as there is danger of efflorescence which will disfigure the work.

The general result of the use of brine at low temperatures has been satisfactory, while the ultimate strength of the concrete is not affected. The use of brine delays freezing at temperatures of about 15 degrees, if it does not wholly prevent freezing before the set has occurred.

Very satisfactory results are obtained also by heating the mixing water and the materials and then protecting the concrete until it has hardened. The simplest way of heating the stone and sand, or gravel, is to set half cylinders of sheet steel on the ground in the form of an arch, light a fire underneath and then dump the material on top. A metal culvert pipe provided with a smaller type for a flue will serve the same way. The water can be heated in any convenient manner. When concrete is placed it must be immediately covered with canvas, and salamanders should be placed under the canvas to

preserve a non-freezing temperature. If stable manure can be kept in place in sufficient quantity to keep up its fermentation, it is the most efficient material for covering.

For concreting in freezing temperatures, a richer mixture should be used, for example 1½:2:4 instead of 1:2:4, and other mixtures in proportion. Only Portland cement should be used, as natural cements will not bear low temperatures as well. As little water as possible should be used, although this will increase the probability of the crumbling of the outer surface of the concrete. Sidewalks should not be laid, nor should cement plastering or finishing be done in freezing weather.

WATER-TIGHTNESS.

Concrete may be rendered water-tight in several ways:

(1) By accurately grading and proportioning the aggregates and the cement.

(2) By special treatment of the surface of the concrete.

(3) By the introduction of foreign ingredients into the mixture.

(4) By the application of layers of water-proof material, such as asphalt and felt.

Where it is specially desirable to obtain absolutely water-tight concrete, it is often advisable to combine two or more of these methods.

Water-Tight Concrete. It is possible to make concrete water-proof by the first of the above methods alone, but this method requires the greatest care in properly grading the material. The stone must be of several sizes grading from a moderate size to a small size, and the same is true of the sand. The proportions of each must be accurately determined by means of a careful test for voids in each size of material, and a general average then taken. The object of such careful grading and proportioning of the materials is to insure a concrete of the maximum density. The methods of grading and proportioning the materials for water-tight concrete is a subject of such magnitude that it would be inconsistent with the general character of this booklet to attempt to describe it here. We recommend that an experienced and competent engineer be consulted for information and advice on this subject before any water-proof concreting is attempted.

The manner of laying the concrete in walls or floors which are to withstand water pressure is as important as the proportioning of its ingredients. The chief points applicable to water-tight work are briefly recapitulated as follows:

(a) Mix concrete of quaking or of wet consistency.

(b) Place concrete carefully so as to leave no visible stone pockets.

(c) Lay the entire structure if possible in one continuous operation, working night and day when necessary.

(d) If joints are unavoidable, clean and roughen the old surface, then wet it and coat with a layer of cement mortar.

(e) Make suitable provision for contraction by special joints, or by steel reinforcement without joints.

The results of careful experimenting and testing for permeability, indicate that the best consistency for concrete designed to withstand water pressure is intermediate between a quaking and a mushy mixture. An excess of water in concrete, however, affects the chemical composition of the cement, and thus reduces both the strength and the water-tightness of the concrete.

Various proportions are used to resist the percolation of water, ranging from 1:1:2 to 1:2½:4½, the most common mixture being 1:2:4 or 1:2½:4½. However, with accurate grading of the materials by scientific methods, water-tight concrete may be obtained with proportions as lean as 1:3:7.

Special Treatment of Surface. Various methods of treating the surface of concrete have been employed to increase its water-tightness with some degree of success.

Plastering the surface of concrete with rich Portland cement mortar in proportions 1:1 or 1:1½ is a method often employed, but in temperate or cold climates it is only useful for walls below the surface of the ground and therefore not subject to atmospheric changes. In such cases it can sometimes be used as a substitute for, or in connection with paper and asphalt.

In certain sections of the Boston Subway, a 6-inch wall of concrete was laid up next to the bank of earth and plastered with a layer of 1:1 cement mortar about ½ inch thick. After spreading the mortar with a plasterer's ordinary metal float, the surface was run over with a toothed roller about 12 inches long by 4 inches in diameter, which pressed the plaster into any crevices, and left a rough surface. The main wall of concrete forming the lining of the subway was then laid up against this plastered surface. On horizontal or inclined surfaces, a granolithic surface of rich mortar of Portland Cement and sand, or Portland cement and screenings in proportions about 1:1 may be laid and troweled, as in sidewalk construction. (See page 24.) The surface finish must be placed at the same time as the base, and with the same, that is Portland, cement. The water-tightness of horizontal or inclined layers of concrete may be greatly increased by troweling the concrete in the same manner that granolithic work is troweled. This brings the cement to the surface, and produces a dense, hard surface which is nearly equal to a surfacing of rich mortar. This is very effective for surfacing a structure like the inclined face of a dam or a concrete floor. In all cases where it is possible, the surfacing should be done on the side which is to come in contact with the water, and if the wall is to be made impervious in both directions, both sides should be surfaced.

Introduction of Foreign Ingredients. The principal advantage in introducing foreign ingredients into a mortar of concrete is to permit

the use of a lean mixture, the fine particles of hydrated lime, or whatever is used, tending to reduce the volume and the dimensions of the voids.

Lime can only be used to advantage with mortars leaner than 1:2 and with concrete leaner than 1:2½:4½. The quantity of lime used depends entirely upon the fineness of the sand used, and the proportions of the mixture. Experiments show that a 1:2½:5 concrete can be made more water-tight, although its strength is slightly reduced, by substituting an equal weight of lime paste for 10 per cent by weight of the cement. Unslaked lime must not be used under any circumstances.

Puzzolan cement, unlike lime, tends to strengthen even the richer mortars, in many cases 20 per cent by weight of the total dry materials being used satisfactorily, if the Puzzolan cement is ground with the Portland. The impermeability of concrete has been greatly increased by this method in many cases.

The Sylvester Process mixture employed in New York harbor by Major W. L. Marshall was made by "taking one part cement and two and one-half parts sand and adding thereto three-quarters of a pound of pulverized alum (dry) to each cubic foot of sand, all of which was first mixed dry, then the proper amount of water—in which had been dissolved about three-quarters of a pound of soft soap to the gallon of water—was added, and the mixing thoroughly completed. The mixture is little inferior in strength to ordinary mortar of the same proportions and is impervious to water, and is also useful in preventing efflorescence."*

Layers of Water-proof Material. Layers of water-proof paper or felt with tar or asphalt between them are often employed for a water-proof course in concrete floors, roofs and walls of underground structures of large or long area, which require protection from the infiltration of water. The materials used in this method range from ordinary tarred paper, laid with coal tar pitch, to asbestos or asphalted felt, laid in asphalt.

"The water-proof layer of a floor may be laid directly on the ground if the soil is fairly dry and firm, but is usually spread upon a layer of concrete from 4 to 8 inches thick. In case the material is to be laid directly upon the ground, the first layer consists of strips with a 2 to 6 inch lap cemented with asphalt, and the remaining layers are mopped on. Upon a concrete base it is customary to first spread a layer of asphalt upon the concrete, although if the concrete is damp, the bottom layer of the paper or felt may be placed dry, as described above. The 'ply' in water-proofing—that is, the number of layers which cover all parts of the surface—varies from 2-ply to 10-ply. It is considered better practice to 'shingle' the strips than to place each ply or layer independently. If the surface to be water-proofed is rough, it may be leveled with cement mortar. It must be dry before applying the tar or asphalt. The asphalt is heated and brought, generally in

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* Report Chief of Engineers, U. S. A., 1901, p. 918.

buckets, to the work. Several rolls of paper are started consecutively. Ahead of each roll, as it is unrolled, the liquid asphalt is swabbed upon the concrete with a mop, so that the paper or felt is spread directly upon the fresh, hot stuff. As soon as the first roll is started the second is placed to overlap the first, a width depending upon the number of ply to be laid. For example, if the felt is 32 inches wide and is laid 3-ply, the second roll is lapped upon the first about 22 inches. As this is unrolled (in the same general direction as the first roll) the surface ahead of it is mopped with asphalt, as described above. A third roll is immediately started, lapping both of the two others, and so on for the entire width of the surface to be covered.

A water-proof course of this character always forms a distinct joint in the mass, thus destroying its cohesion upon that plane, and the strength of the concrete in bending on the two sides of the layer must be considered independently."*

Asphalt is sometimes laid as a water-proof course in one or more continuous sheets, and is also used for filling contraction joints in concrete.

COST OF CONCRETE WORK.

The cost of concrete work varies so greatly in different kinds of work, and in different localities that it is obviously impossible to give any definite figures that will apply to all conditions on even one class of work. Labor, cement, sand, stone and lumber, differ greatly in cost in each section. The excavation and filling conditions will be different on each separate job. Then again, one foreman, with his men, can put in a job in as much as from 20 to 30 per cent less time than can another foreman with his gang, or even with the same gang. The foreman plays a very important part in fixing the cost of a job, since upon him depends to a large degree the most variable item of cost, namely, the time required to put in the work. Weather conditions also affect the cost of the job, and should whenever possible be taken into consideration. But while we cannot give any specific figures as to the cost of concrete work, we can outline in a general way the methods of cost figuring. Knowing the cost of labor and material in your own locality, and knowing the conditions under which the work is to be done, you can estimate the cost of a job by following these instructions.

In order to figure the cost of concrete it is necessary to know the amounts of the various ingredients required for a certain proportioned mix. Below is a table which will furnish you with this information:

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*Taylor & Thompson, Concrete Plain and Reinforced, 1905, page 422.

QUANTITIES OF INGREDIENTS REQUIRED FOR ONE CUBIC YARD OF RAMMED CONCRETE

Proportion of Mix—Stone 2 in. an Under, Dust Screened Out			Ingredients Required		
Cement	Sand	Crushed Stone	Bbls. Cement	Sand Cu. Yds.	Stone Cu. Yds.
1	1.5	3	1.91	0.42	0.85
1	2	3	1.74	0.52	0.77
1	2	4	1.51	0.45	0.89
1	2	5	1.29	0.39	0.98
1	2.5	4	1.38	0.53	0.84
1	2.5	4.5	1.31	0.48	0.87
1	2.5	5	1.24	0.46	0.92
1	3	5	1.16	0.52	0.86
1	2.5	6	1.07	0.41	0.98
1	1	Top Dressing	4.88	0.72	....
1	1½		3.87	0.86	....
1	2		3.40	1.02	....

1 barrel cement equals 4 bags equals 4 cubic feet

Cost of Sidewalks. The items to be figured for the ordinary walk are:

Material. Amount of concrete, and its cost
Sand
Stone
Cement

Amount and cost of top-dressing
Sand
Cement

Amount and cost of cinders or gravel sub-base
Amount and cost of lumber for forms.

Labor. Excavating or filling for sub-base
Placing cinders
Placing and removing forms
Mixing and placing concrete
Mixing, placing and finishing top-dressing

Take for example a walk 100 feet long and 6 feet wide, consisting of one inch top coat, 4 inches of concrete and 4 inches of cinders. The area of this walk will be 600 square feet. The volume of cinders used in cubic feet will be 600 divided by 3, or 200 cubic feet, which in cubic yards is 200 divided by 27, or 7.40 cubic yards. If cinders cost 40 cents a yard delivered, the cost of cinders is $2.96. To get the cost of the concrete, the ingredients, sand, stone and cement, must be figured separately. First decide upon your mixture. Then from the above table you can determine the amounts of each ingredient required for the walk. For example, to get the cost of the stone: Say we use a mixture of 1:3:5. For this mixture, the table gives the

amount of stone to be used per cubic yard of concrete as 0.86. The number of yards of concrete in the walk is 600 divided by 3, divided by 27 or 7.40 cubic yards. The volume of stone used then is 7.40 multiplied by 0.86 or 6.36 cubic yards. Say the stone costs $1.40 per yard delivered; then the cost of stone for the walk is $8.90. Then by the same method figure the amount and cost of the sand used, and also the cement. With sand costing $1.40 delivered, its total cost for the walk will be $5.38. At $1.35 a barrel the cement used will cost $11.58. The total cost of concrete material then is $25.87. Using the same method, the top-dressing will figure out at $11.12. The cost of the water is so small that it can be ignored.

For the forms, all the lumber needed are the 2 x 4 pieces for the sides, the stakes to hold them in place and 2 x 4 cross-pieces. If the builder already has the lumber, this item need not be figured; but where new lumber must be purchased it figures about as follows:

20 2 x 4 x 10 for the sides at 18c	$3.60
17 cross-pieces 2 x 4 x 6 at 11c	1.87
Total	$5.47

Any odd pieces can be used for stakes, so this item need not be considered.

The materials and costs for 100 feet of sidewalk, 6 feet wide and 5 inches thick, are itemized then as follows:

Cinders		$ 2.96
Concrete	Cement	11.58
	Sand	5.38
	Stone	8.90
Top	Cement	8.94
	Sand	2.63
Lumber		5.47
Total		$45.86

The cost of labor is a much more difficult item to figure, because of the varying conditions. Only an experienced contractor or engineer, knowing the local conditions of the work and the efficiency of his men and foreman, can figure this item accurately; and even then, unforeseen conditions may arise which would render even his figure far from correct. The labor item may be estimated under average conditions, but it is a problem entirely for the individual, and accurate figures cannot be given by an outsider unfamiliar with the local conditions. Where a person desires to use a general approximation as the basis for figuring his labor cost, he can figure on putting in a sidewalk or floor for 3 to 3½ cents a square foot when mixing by hand and

$2\frac{1}{2}$ to $2\frac{3}{4}$ cents a square foot when mixing by machine. These figures include all the labor required for the work, but it must be remembered that they are only approximations covering work under average conditions.

In estimating the labor cost the following items must be figured:

Excavating and tamping foundation
Placing and tamping cinders
Erecting forms
Mixing, placing and tamping the concrete
Mixing, placing and finishing top coat
Removing forms and back-filling excavation.

The time required for each item must be estimated and when the total is determined, it is easy to figure the cost.

Floors. The cost of floors is figured in just about the same manner as that of sidewalks, and in general the same items will appear in the cost column. The same is true of concrete driveways. The cost of walls and foundations is figured in a slightly different way.

Cost of Walls and Foundations. The items to be considered in figuring the cost of walls and foundations, are in general the same as for sidewalks and floors, namely:

- Material—
  - Forms—
    - Studs
    - Braces
    - Facing
    - Wire
    - Nails
    - Spacing Blocks
    - Cleats
  - Concrete—
    - Cement
    - Sand
    - Stone
    - Reinforcing (if necessary)
- Labor—
  - Excavating and teaming away
  - Erecting forms
  - Mixing and placing concrete
  - Removing forms
  - Back filling
  - Placing the reinforcing

As in the case of sidewalks and floors, an estimate of the time required for the work must be taken and the labor figured accordingly. It has been estimated that the concrete can be mixed and placed for wall work at a labor cost of from 80c to $1.25 per cubic yard, when

using a concrete mixer. When estimating the cost of the forms, it is safe to figure on using the facing lumber 4 times, if it is handled carefully. Where a wall is straight without any off-sets, the forms can be erected and taken down for 2½ to 3 cents a square foot. This figure includes the cost of wire and nails, but not the price of the lumber. Where the wall is not straight and contains off-sets, the cost will increase according to the number of off-sets. Where a smooth wall is desired, and tongued and grooved lumber is used, the cost of erecting and pulling down the forms will run as high as 6 to 6½ cents, not including cost of lumber.

The cost of excavating is an extremely variable quantity. One man can shovel more than another. The ground may be loose and easy to remove; or it may be hard and require considerable picking. The ground may be wet or dry—another important factor in the cost of excavating. Where the earth must be taken away, the cost of loading and teaming must be considered. And then again some of the ground must be left for the back-filling.

To estimate the cost of the concrete for a wall or foundation, it is necessary to figure the cubical contents of the wall—that is, the amount of concrete necessary in cubic yards. Then when the mixture is decided upon, the amounts of each ingredient in each cubic yard of concrete can be determined from the table on page 33, and then, knowing the total number of cubic yards in the wall, the cost can easily be figured. The number of reinforcing rods required (if any) can be determined as described on page 21.

In order to give the reader a general idea as to cost of sidewalk and floor construction, we have listed below the actual cost of a sidewalk and concrete floor, in the city of Milwaukee.

Cost of Sidewalk:

200 feet long, 5 feet wide, 4 inches concrete base, 1 inch top coat, mixture 1:3:5. Top 1:2.

Cinders, 3 inches thick, placed and tamped	$ 6.00
Sand, stone, cement for concrete base	44.20
Labor—mixing, placing, tamping concrete	12.30
Sand and cement for top coat	28.00
Placing and finishing top coat	4.00
Total cost	$94.50

Sand at $1.40 per yard, stone at $1.50 per yard.
Cement at $1.35 per bbl. Labor on forms included.

Cost of Floor:

50 feet long, 35 feet wide, 3 inches concrete base, Top coat ½ inch; mixture 1:3:5. Top coat 1:2. Price of materials same as above.

Sand, stone, cement for concrete base	$ 57.92

Labor—mixing and placing concrete and grading sub-base (no excavating)	16.10
Sand and cement for top coat	24.50
Placing and finishing top coat	7.00
Total cost	$105.52

MACHINE VS. HAND-MIXED CONCRETE.

In the comparison of machine and hand-mixed concrete, two very important items are to be considered; first, the comparative quality of the concrete, and second, the comparative cost of mixing the concrete. After years of testing and comparison, the result is no longer in doubt but is now a well established and generally acknowledged fact.

Quality of the Concrete. In comparing the specifications for any certain kind of concrete construction for the past few years, it will be seen that there is a steady increase in the amount of cement used as compared with the other ingredients. In other words, concrete engineers throughout the country realize that since concrete structures are built to last, good concrete must be used—concrete with a sufficient amount of cement in it to make it of maximum strength, regardless of the increased cost. In order to be strong concrete, it must not only have the proper proportion of cement, but it must be thoroughly and uniformly mixed. No matter how much cement is used, the concrete cannot have the required strength unless it is well mixed. It is now generally acknowledged that perfectly mixed concrete can be produced economically only by the use of a high grade batch mixer. Architects recognize this fact when they specify the use of a batch mixer, and the general public continually acknowledge it when they repeatedly give the preference by letting their concrete work to the man with the mixer. Most authorities give the strength of the machine mixture as 15 per cent to 20 per cent more than a hand-mixed concrete. Some give even 25 per cent and quote from carefully conducted tests to bear them out. Even if it were not an actual saving, it would be cheap as good insurance against failure due to careless mixing. It means that the full value of the cement used will be developed.

Comparative Cost. The comparison of machine and hand-mixed concrete is made even stronger when the cost of the two methods is considered. BETTER CONCRETE BY MACHINE FOR LESS MONEY—that is the universal verdict, and that verdict has been reached only as the result of the most careful tests, and the compiling and careful examination of a large amount of reliable data. In one of the recent numbers of "THE CONTRACTOR" is an article by C. W. Gaylord, C. E., entitled, "Machine vs. Hand-Mixed Concrete." This article contains some very interesting data on this subject, some of which is quoted below: "Actual cost of hand mixing of concrete under favorable conditions in Riverside, California, during 1909. Concrete placed in 6-inch wall. Labor efficient and experienced. The crew consisted of:

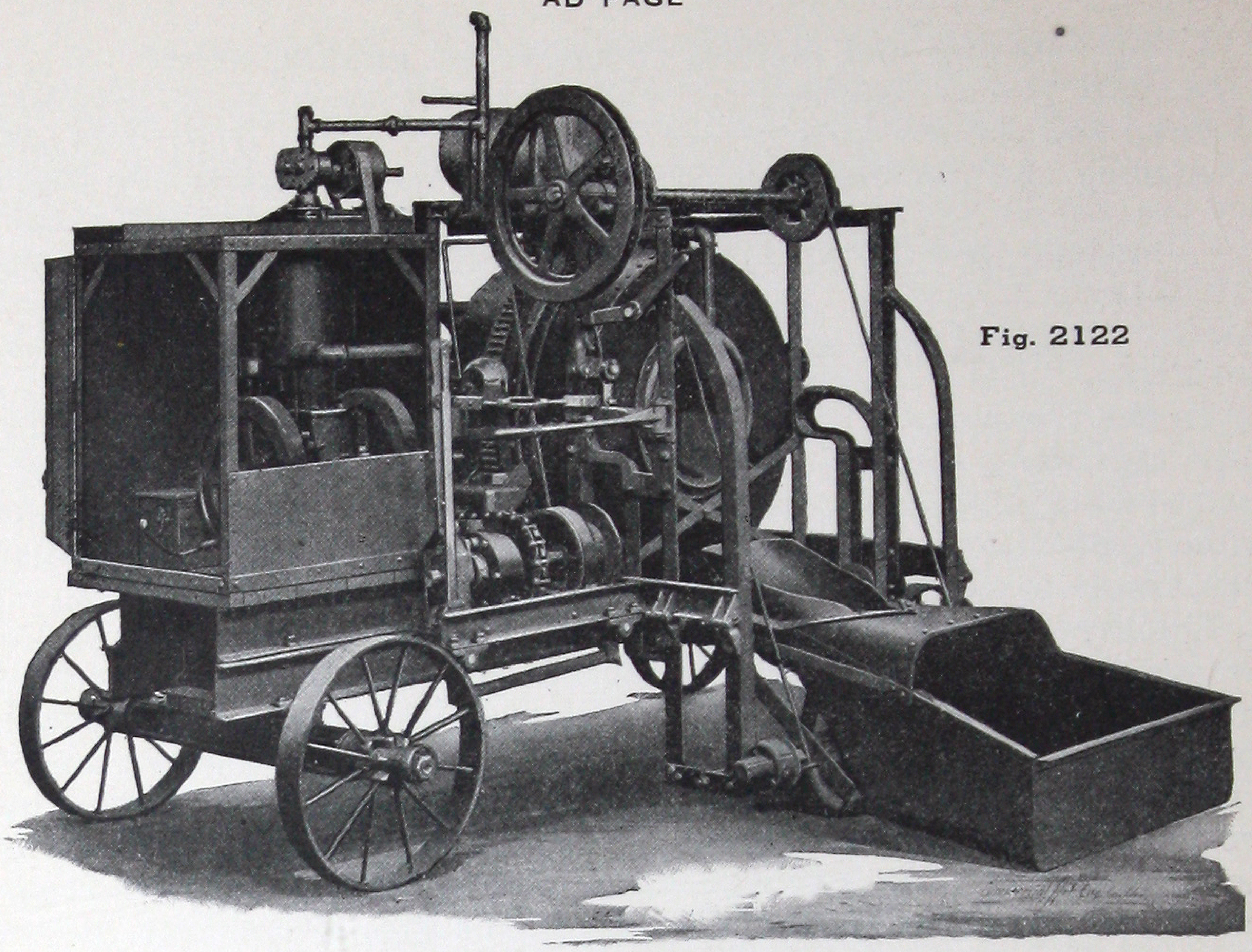

Fig. 2122

SMITH-CHICAGO MIXERS.

The Smith-Chicago Mixer is splendidly adapted to handle any class of concrete work—it has **all** the essential features that make a fast and economical mixer. Briefly summarized, here are the why's of the Smith-Chicago Mixer:

Big, steep-angled scoop blades that mix well and empty clean and rapidly;

Concaved drip ring that permits the discharge chute to penetrate well beyond drum center;

Steep discharge chute that will empty a one-yard batch in less than 18 seconds—a chute that operates from either side of the mixer—one that will discharge the entire batch or any portion of it quickly and easily;

Central drive ring combining main roller tracks and gear ring in one solid casting, thus preserving perfect alignment of all driving parts;

Vertical acting power charger that lifts easily, discharges rapidly and without spilling or clogging;

There are other important "why's." Get our catalog and read about them. Send for Smith-Chicago Catalog No. 122.

SMITH-CHICAGO MIXER CAPACITIES, WEIGHTS, ETC.

Number of Mixer	504	506	509	514	520	527	540	554
Size of batch, mixed concrete, cu. ft.	4	6	9	14	20	27	40	54
Practical proportions cement, sand and crushed stone	1:2:3½	1:3:6	1:4:8 2:4:8	2:6:12 3:6:12	3:9:18 4:8:16	3:12 :24 4:12 :24 5:12½:25	4:16 :32 6:18 :36 7:17½:35 9:18 :36	6:24 :48 8:24 :48 9:22½:45 12:24:48
Output (45 batches) in loose mixed material per hour, cu. yds.	6½	10	15	24	32	45	66	90
Horse power required	2	4	6	8	10	14	20	35
Speed of drum, R. P. M.	12	12	12	10	9	9	9	8

Complete table given in our large catalog. Ask for Smith-Chicago Mixer Catalog No. 122.

The T. L. Smith Co.——3133 Hadley Street——Milwaukee, Wis.

Foreman	$ 3.00	per day
Two men at $2.25	4.50	
Eight men at $2.00	16.00	
Total	$23.50	per day

This crew averaged 12 batches of concrete per 9-hour day, each batch containing 1.7 cubic yards, or 20.4 cubic yards yer day. The material handled was:

84 Sacks Cement.
9.8 Cubic Yards Sand.
19.6 Cubic Yards Stone, 1½ inches and under.

This is over 2 cubic yards per man, per 9-hour day, of finished concrete, including all work except forms. The average given by most authorities is from 1¼ to 1¾ cubic yards per man per 10-hour day. This shows the ability and efficiency of this foreman and crew, and proves this to be a very pertinent case to compare with machine mixing.

The cost of mixing and placing the concrete was $23.50 divided by 20.4 equals—$1.15 per cubic yard.

To this must be added the cost of mixing boards, which figures per cubic yard at 4 cents. The total cost of the hand-mixed concrete per cubic yard then was $1.19.

Under exactly similar conditions, the cost of 1 cubic yard for machine-mixed concrete would be as follows:

Mixing concrete and loading mixer, including labor, gasoline, etc.		.34 per cu. yd.
Placing mixed concrete, wheeling, etc.		.24 per cu. yd.
Cost of mixer	$600.00	
One-half estimated life of mixer in cu. yds.	10000.	
Repairs for 10,000 yds.	$200.00	
	$800.00	
Salvage in mixer	100.00	
	$700.00	
Cost per cu. yd. of mixer		.07 per cu. yd.
		.65 total cost per cu. yd.

$1.19 minus $0.65 equals $0.54 total saving per cu. yd.

This means a saving of 54 cents on every cubic yard of concrete mixed; a saving of over 45 per cent.

A question is always raised here by the adherent to the old-fashioned hand mixing: "But how about the man who uses only 2,000 to 3,000 cubic yards of concrete per year? He would have to wait four years and use his machine for that length of time before he gets

the full advantage of the 54 cents per cubic yard saving. He might not be in business by that time." Figure the saving from another point of view. Say the user produces 2,500 cubic yards per annum. The difference between hand and machine mixing, without considering the cost of the machine, is $1.19 minus 58 cents or 61 cents saving per cubic yard. 2,500 multiplied by $0.61 equals $1,525.00. Deduct the cost of the machine, $600.00, and there is a saving for one year of $925.00, 150 per cent of the cost of the machine. The machine operated the second year, the $1,525.00 is all saved, less the cost of the repairs and maintenance for the mixer. One does not have to figure four years. The machine has paid for itself the first year twice over."

Mr. Gaylord's figures coincide in general with all the tests and investigations on this subject. The mixer pays for itself, increases the profits, lowers the cost, produces more and better concrete, and eliminates the "personal equation" that enters so prominently into concrete work, where the mixing is done by hand.

INFORMATION.

THE T. L. SMITH CO. will be glad of a chance to assist its friends and customers to solve the problems constantly arising in the use of concrete. Whenever we have the desired information at hand we will furnish same immediately upon request, and will be pleased to get such information, wherever possible, which we have not at hand. This advice is free and involves no obligation whatever.

In writing for information, time will be saved if the inquiry is made full and explicit. Prompt attention will be given every request for information.

Address

THE T. L. SMITH CO.,
Milwaukee, Wis., U. S. A.

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